National Aeronautics and
Space Administration

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Communications, Navigation, and Networking reConfigurable Testbed (CoNNeCT) Project

National Aeronautics and Space Administration
John H. Glenn Research Center at Lewis Field, OH 44135

CoNNeCT PROJECT PLAN

AUTHORIZED by CM when under FORMAL Configuration Control	
Date	**Signature**
02/03/2012	*/s/ James A. Drury*

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PREFACE

National Aeronautics and Space Administration (NASA) is developing an on-orbit, adaptable, Software Defined Radios (SDR)/Space Telecommunications Radio System (STRS)-based testbed facility to conduct a suite of experiments to advance technologies, reduce risk, and enable future mission capabilities on the International Space Station (ISS). The Communications, Navigation, and Networking reConfigurable Testbed (CoNNeCT) Project will provide NASA, industry, other Government agencies, and academic partners the opportunity to develop and field communications, navigation, and networking technologies in the laboratory and space environment based on reconfigurable, software defined radio platforms and the STRS Architecture. The CoNNeCT Payload Operations Nomenclature is “SCAN Testbed” and this nomenclature will be used in all ISS integration, safety, verification, and operations documentation. Also included are the required support efforts for Mission Integration and Operations, consisting of a ground system and the Glenn Telescience Support Center (GRC TSC). This document has been prepared in accordance with NASA Glenn’s Configuration Management Procedural Requirements GLPR 8040.1 and applies to the CoNNeCT configuration management activities performed at NASA’s Glenn Research Center (GRC). This document is consistent with the requirements of SSP 41170, Configuration Management Requirements, International Space Station, and Space Assurance Requirements and Guidelines (SARG).

This document defines, at a high level, the scope of the project, the implementation approach, the environment within which the project operates, and the baseline commitments of the program and project.

DOCUMENT HISTORY LOG

Status (Preliminary/ Baseline/ Revision/ Canceled)	Document Revision	Effective Date	Description
Preliminary		05/2008	Preliminary Project Plan (SRR version)
Preliminary	Draft	07/24/2009	Pre-PDR submittal. Updated and dispositioned all review feedback received since Preliminary (SRR) version. Resources and schedule are not updated and will be in late august release. (Formatting of tables, figures, needs fixed.)
Preliminary	Draft	08/25/2009	Pre-PDR second iteration for PRB. Includes comments from CCB and GRC Program Review (out-of-board) Board. Includes updated PDR cost, schedule, and mission success.
Baseline	-	11/09/2009	Post-PDR final version for HQ signature and baseline including suggested clarifications from PDR Board.
Revision	A	12/07/2010	Updated post CDR to reflect HTV-3 launch slip, modified budget, and other changes to project execution. Incorporated Change Request CONN-CR-0325
Revision	B	12/07/2011	Include Phase E and F of project life cycle and CoNNeCT Experiments scope. Updated schedule to address latest HTV-3 launch schedule. Modified through 2018. Correspondingly updated other changes to project execution consistent with this life cycle phase. Incorporated Change Request CONN-CR-0543.

SIGNATURE PAGE

Prepared By:

/s/ Michael J. Zernic	*12/16/2011*
Michael J. Zernic CoNNeCT Deputy Project Manager John H. Glenn Research Center at Lewis Field	Date

Concurred By:

/s/ Diane C. Malarik	*12/16/2011*
Diane C. Malarik CoNNeCT Project Manager John H. Glenn Research Center at Lewis Field	Date
/s/ Jih-Fen Lei	*12/16/2011*
Dr. Jih-Fen Lei, Director Research and Technology Directorate John H. Glenn Research Center at Lewis Field	Date
/s/ Timothy D. Best for	*12/16/2011*
Anita D. Liang, Director Office of Safety and Mission Assurance John H. Glenn Research Center at Lewis Field	Date
/s/ Richard T. Manella for	*12/16/2011*
Thomas W. Hartline, Director Engineering Directorate John H. Glenn Research Center at Lewis Field	Date

Approved By:

/s/ Bryan K. Smith	*12/16/2011*
Bryan K. Smith Space Flight Systems Directorate John H. Glenn Research Center at Lewis Field	Date
/s/ Ramon Lugo	*01/30/2012*
Ramon Lugo Director John H. Glenn Research Center at Lewis Field	Date

SIGNATURE PAGE, CONCLUDED

/s/ Badri A. Younes	*01/13/2012*
Badri Younes, Deputy Associate Administrator Space Communications & Navigation (SCaN) Program Office NASA Headquarters	Date

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1.0 INTRODUCTION

1.1 Introduction

As stated in the Preface, NASA is developing an on-orbit, adaptable, SDR/STRS-based testbed facility, managed as the Communications, Navigation, and Networking reConfigurable Testbed (CoNNeCT) Project, to conduct a suite of communication, networking and navigation experiments on the International Space Station (ISS). This Project Plan defines, at a high level, the scope of the project, the implementation approach, the environment within which the project operates, and the baseline commitments of the program and project.

The CoNNeCT project is sponsored by the SCaN Program of NASA's Human Exploration and Operations Mission Directorate (HEOMD). HEOMD is responsible for developing, fielding and operating the Agency's communications and navigation infrastructure in support of the Agency's various missions. As such, SCaN (through its technology development program) sponsors key technology and standards development activities to enable the next generation communications and navigation infrastructure to meet future NASA missions' needs. In addition to enabling HEOMD's communications and navigation infrastructure mission, key technologies demonstrated by the SCAN Testbed in the relevant space environment facilitates their utilization by any mission sponsored or serviced by HEOMD.

The CoNNeCT project is defined as the design, build, launch, and operations of the SCAN Testbed and its experiments. It includes the necessary ground and flight systems to support the development and subsequent utilization of the payload, as well as eventual payload decommissioning and project closeout, The project includes an initial suite of experiment capabilities, the development of all ground systems, procedures and plans required to integrate and operate the payload on ISS, and the sustaining engineering, integration, and mission operations function for utilizing the Flight and Ground System. In addition, the project is responsible for experiment development and operations. Project closeout (Phase F) will occur no earlier than 2018 with SCAN Testbed decommissioning, disposal, and final documentation. Upon completion of all closeout activities, the project will be terminated.

Project resources do not include costs of carrier integration, launch services, or Space Network and Near Earth Network service costs. These costs are addressed by the ISS Program and/or the SCaN program and are outside the project's scope or control. Additionally, the cost of non-SCaN funded experiments, such as those developed by other Government agencies or the Small Business Innovative Research (SBIR) program, are not included in the scope of the project resources,

The CoNNeCT project is classified as a Class D payload per NPR 8705.4 and as a Category 3 level project per NPR 7120.5D. The individual experiment-unique activities of the CoNNeCT project will be managed per the requirements of NPR 7120.8, during ground development phase. At the completion of ground development, the experiment will transition to flight status, and implementation will be consistent with NPR 7120.5D. The project received Authority to Proceed (ATP) from SCaN in April 2008, and held a combined Mission Concept Review/System Requirements Review (MCR/SRR) in May 2008. Baselined Level I requirements were received from SCaN in July 2008 and revised on July 2009. The project developed an integrated information package outlining its requirements, technical concept, schedule, resources, risks and management approach for GRC senior management review and approval. GRC approval by the cognizant GRC senior management was received in October 2008. The project completed its Preliminary Design

Review in Sept 2009, its Critical Design Review (CDR) in April 2010, its System Acceptance Review in October 2011, and is scheduled for launch in the summer of 2012.

1.1.1 Applicable Documents

The documents listed in this paragraph are applicable to the extent specified herein.

Document Number	Document Title
GRC-CONN-PLAN-0002	CoNNeCT Configuration Management Plan
GRC-CONN-PLAN-0005	CoNNeCT System Engineering Management Plan
GRC-CONN-PLAN-0006	CoNNeCT Product Assurance Plan
GRC-CONN-PLAN-0007	CoNNeCT Risk Management Plan
GRC-CONN-PLAN-0024	CoNNeCT Software Management and Development Plan
GRC-CONN-PLAN-0026	CoNNeCT Operational Concept Document
GRC-CONN-PLAN-0045	CoNNeCT Integrated Logistics Support Plan
GRC-CONN-PLAN-0085	CoNNeCT Software Assurance Plan
GRC-CONN-PLAN-0089	CoNNeCT Project Decommissioning/Disposal Plan
GRC-CONN-PLAN-0133	CoNNeCT Project Mission Operations Plan
GRC-CONN-REQ-0019	CoNNeCT Project Level 1 Requirements
GRC-CONN-RPT-0227	CoNNeCT Fault Detection Isolation and Recovery Document
GRC-CONN-RPT-0099	CoNNeCT Project Mission Success Criteria
NPD 1440.6	NASA Records Management
NPD 2190.1A	NASA Export Control Program
NPD 2200.1	Management of NASA Scientific and Technical Information
NPR 2200.2B	NASA Requirements for Documentation, Approval, and Dissemination of NASA Scientific and Technical Information.
NPD 2810.1	NASA Information Security Policy
NPR 1441.1	NASA Records Retention Schedules.
NPR 7120.5D	NASA Space Flight Program and Project Management Requirements
NPR 7120.6	NASA Lesson Learned Process
NPR 7120.8	NASA Research and Technology Program and Project Management Requirements
NPR 7123.1	NASA Space Flight Program Systems Engineering Management Requirements
NPR 7150.2	NASA Software Engineering Requirements
NPR 8621.1Be	NASA Procedural Requirements for Mishap and Close Call Reporting

1.1.2 Reference Documents

The following documents contain supplemental information to guide the user in the application of this document.

Document Number	Document Title
GRC-CONN-PLN-0857	CoNNeCT Research and Technology Management Plan
NPD 2820.1	NASA Software Policy.
NPR 8000.4	NASA Risk Management Procedural Requirements

1.2 Objectives

CoNNeCT, as an ISS testbed to advance communications technology, provides a reconfigurable orbiting test and demonstration environment for space communications, navigation, and networking devices. This includes Software Defined Radios (SDRs), transmitters, receivers, antennas, network interfaces, and other peripheral devices required for complete space communication and navigation systems. The CoNNeCT project, through its experiment phase, provides broad relevance to numerous NASA programs and missions including:

1) NASA program operations and technology (e.g., Reconfigurable SDR technology development and operations for future missions),

2) SCaN Program infrastructure and mission services upgrades (e.g., demonstration of bi-directional Ka-band links, on-orbit reconfiguration, Space Network (SN) Ground Segment Sustainment (SGSS) users), including Delay/Disruption Tolerant Networking (DTN),

3) SCaN Program technology and standards advancement (e.g., SDR and STRS advancement, networking and interoperability with higher networking layers).

These relevance areas are depicted in Figure 1-1.

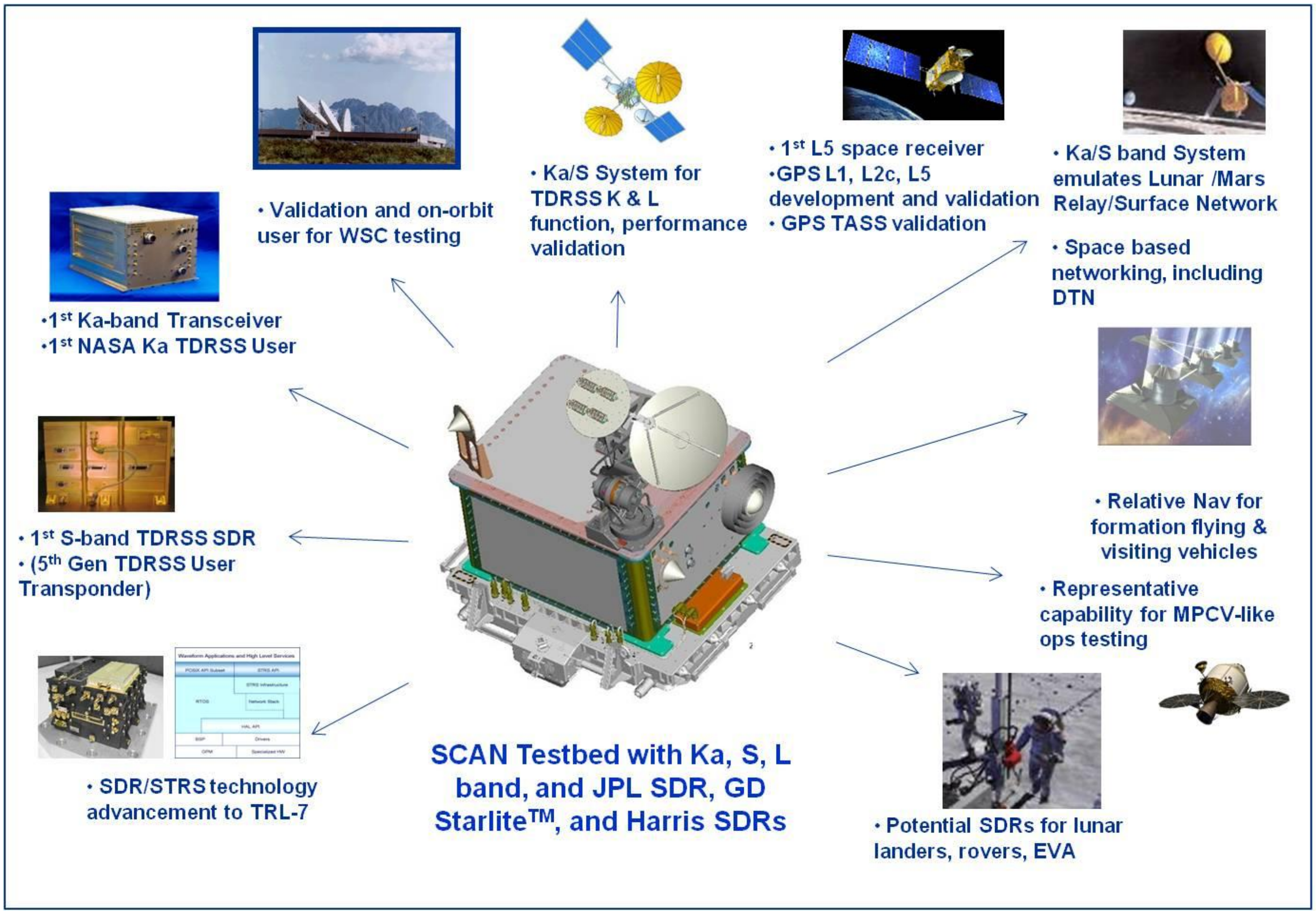


Figure 1-1—CoNNeCT Relevance

The CoNNeCT Project provides the development and operation of the software defined radios compliant to a single SDR architecture standard, the Space Telecommunications Radio System (STRS). Although SDRs are being deployed in commercial and military ground applications, SDRs for the space domain remain relatively new and not thoroughly tested, especially for human spaceflight. NASA continues to develop and operate traditional radio systems that are typically not reconfigurable post launch. Through its on-orbit experiment demonstrations, CoNNeCT furthers an entirely new paradigm of reconfigurable capability for NASA to enable new operations, and new modes of fault recovery enabled by the reconfigurable nature of the CoNNeCT SDRs and avionics subsystems.

The STRS Architecture is an open architecture standard for SDRs developed for NASA for both space and ground. If adopted, this architecture reduces dependence on ad hoc implementations, which have inherent risks associated with them. Past implementations left NASA dependent upon proprietary developments, with unique operation and test interfaces, and varying hardware descriptions, software development artifacts, and documentation standards. These developments are typically not extensible or scalable, and do not enable design reuse or other economies of a standard, open-architecture approach. STRS standardizes certain interface and documentation to reduce the uncertainty and differences across developments. This, in turn, enables broader participation by industry and academia because multiple suppliers can readily be tested, accepted, and integrated. Furthermore, an open architecture standard enables different vendors to provide radios that conform to the interface standard thus providing commonality among different implementations at the operation and test interfaces and enabling interoperability between providers of different hardware and software elements.

Simply stated, the CoNNeCT project goals are to:

- Enable on-orbit experiments to support continuing development of the STRS standard
- Advance communications, navigation, and networking technologies
- Enable future mission capabilities
- Reduce programmatic, development, and operational risks of future missions

The specific CoNNeCT project objectives are to:

1. Use reconfigurable systems to validate different communications capabilities and advance the Technology Readiness Level (TRL) to seven (7) of laboratory SDRs, the STRS standard, proposed waveforms, access schemes, architecture flight software, and operational concepts.

    a. Include RF systems operating at S-band, Ka-band, and L-band, and command and data handling and networking systems.

2. Test technologies for HEOMD and other NASA mission directorates' communications and networking for risk reduction.

    a. Surface-Space relay emulation

        i. Ka-band forward link and return links via TDRSS, at data rates representative of Lunar Relay and/or Lunar network capabilities up to 6 Mbps forward and 25 Mbps return, transmitting up to 100 Mbps internally and/or externally generated, using SA connectivity.

        ii. S-band and Ka-band capabilities, such as S-band low data rate links simultaneously with Ka-band high data rate links, utilizing multiple SDRs.

    b. S-band forward link and return links via TDRSS, including, at minimum, data rates at 72 kbps forward and 192 kbps return, using SA and MA connectivity.

3. Demonstrate on-orbit SDR/STRS performance and operations from multiple suppliers.

4. Conduct navigation experiments to include verifying tracking and performance of SDR-based GPS, tracking and performance of TDRSS Augmentation Service for Satellites (TASS)-augmented GPS, and TDRSS tracking and ranging.

5. Conduct communications and networking experiments to assess DTN protocols, on-board routing, and potentially other Command, Control, Communications and Information (C3I) concepts.

1.3 Mission Description

The CoNNeCT System is an integrated system comprised of a ground element and flight element. The flight element (or payload) launches to the International Space Station (ISS) on a JAXA H-II Transfer Vehicle (HTV). The SCAN Testbed is a Flight Releasable Attachment Mechanism (FRAM)-based payload to be installed on a ram-facing, zenith-facing Expedite the Processing of Experiments to Space Station (EXPRESS) Logistics Carrier (ELC) at the ISS P3 location. The SCAN Testbed is transferred and installed to the ELC via Extravehicular Robotics (EVR) activity (Extravehicular Activity (EVA) is the back-up).

The SCAN Testbed is designed to operate for a minimum of two years. The flight element operates three Software Defined Radios (SDRs) that provide duplex S-band microwave RF (Radio Frequency) links with the ground, duplex S-band microwave RF links with the Tracking and Data Relay Satellite System (TDRSS; also referred to as the Space Network (SN), duplex Ka-band microwave RF links with TDRSS and a receive-only L-band microwave RF link with the Global Positioning System (GPS). The flight system communicates with the SN over TDRSS at Ka and S-band as well as directly to ground stations over S-band. The Flight and Ground Systems send and receive commands and data, and manipulate (store, route, and process) data. These operations are notionally depicted in Figure 1-2.

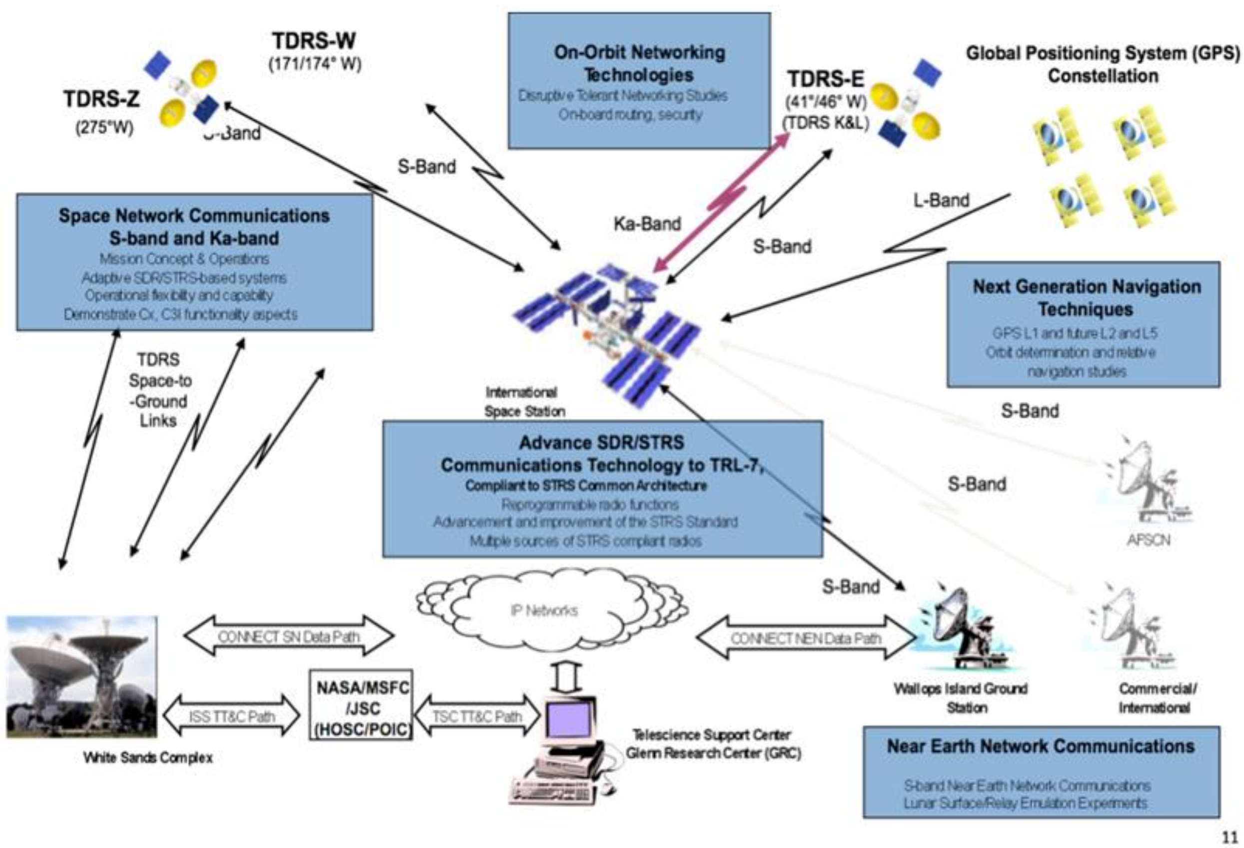


Figure 1-2—CoNNeCT Flight and Ground Mission Operations

At the end-of-life the payload is decommissioned in place and disposed of by the ISS as outlined in the CoNNeCT Disposal Plan GRC-CONN-PLAN-0089.

1.4 Technical Approach

1.4.1 Flight System Architecture

Three SDRs that are compliant to the STRS architecture standard are the core of the on-orbit SCAN Testbed, with RF systems operating at S-band, Ka-band, and L-band. The flight system and ground systems are designed to provide accommodations and operations of these radios.

These SDRs form the core on-orbit capability to be exercised and for which experiments and technology demonstrations will be conducted.. The Jet Propulsion Lab (JPL) provides one radio operating at S-band (transmits and receives) and has an associated L-band receive-only capability (for access to Global Positioning System (GPS) signals). The other two radios were selected via a NASA Research Announcement (NRA). The Harris Corporation provides a radio operating at the Ka-band (transmit and receive capability). The remaining radio is provided by the General Dynamics (GD) Corporation and is based on the GD Starlight architecture operating at S-band (transmit and receive). Both the Harris and GD radios are delivered under cooperative agreements to GRC.

The SDRs are launched with three baseline TDRSS waveforms: two S-band waveforms (one each in the JPL and GD radio) and one Ka-band waveform in the Harris radio. The TDRSS waveforms resident in the GD and Harris radios are developed by the industry SDR providers and delivered as an integral part of the radios. The TDRSS waveform for the JPL radio is developed by a GRC and GSFC waveform team and ported into the radio prior to launch. In addition, the JPL radio hardware accommodates the uploading (post-launch) and operation of GPS waveforms.

The flight system provides infrastructure to support operations of the three software defined radios. The infrastructure is comprised of a Mechanical Subsystem (which includes Thermal and Structural), an Avionics Subsystem (which includes Electrical and C&DH), a RF Subsystem, an Antenna Pointing System (APS), and Software. The flight system also includes the ISS Program-provided FRAM interface hardware known as the EXPRESS Pallet Adapter (ExPA). These subsystems provide the interface to the carriers and environments, as well as structural support, environmental control, commanding, data transfer, data processing, data storage, data routing, power control/distribution, RF signal switching, amplification, transmission and reception, and satellite pointing and tracking. The flight system, radios, and infrastructure components are shown in Figure 1-3.

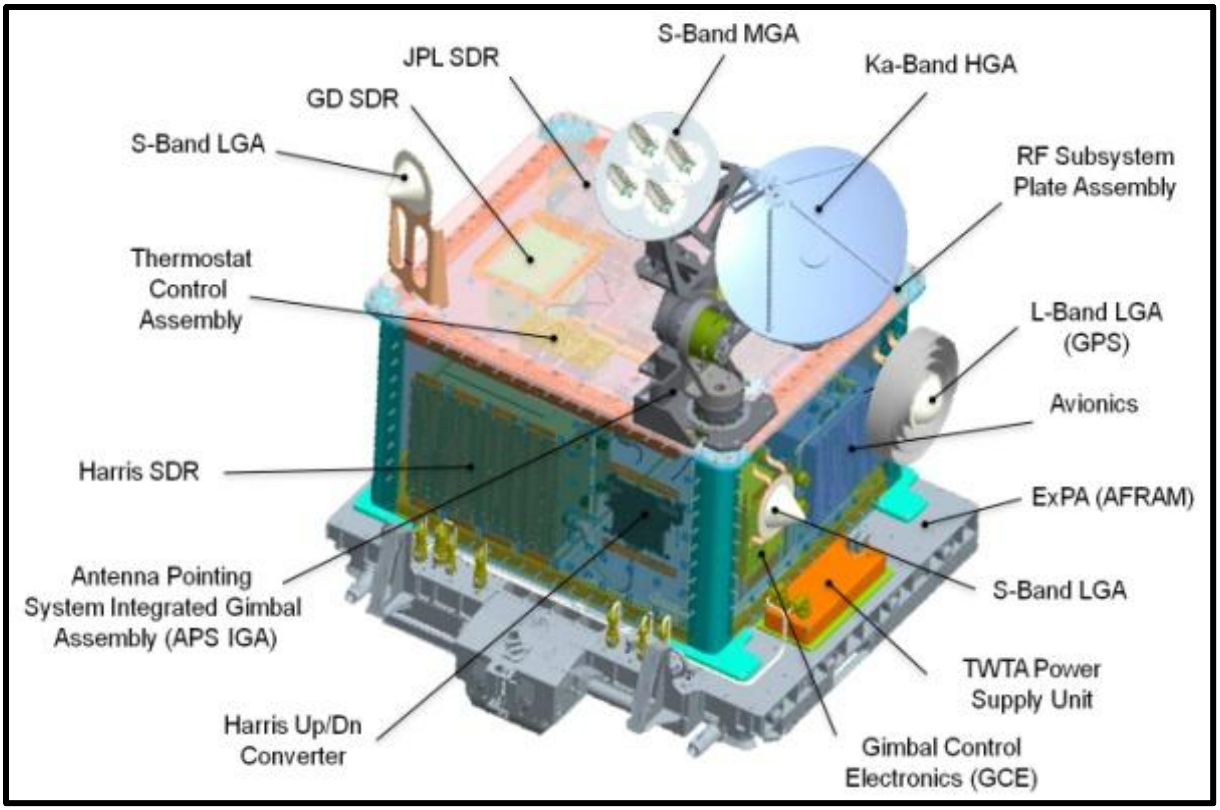


Figure 1-3—CoNNeCT Flight System

The Mechanical accommodations include ExPA, which is in turn mounted to a Japanese Aerospace Exploration Agency (JAXA) multi-purpose Exposed Pallet (EP MP). On orbit, the SCAN Testbed[1] is installed on an ELC located on the exterior truss of the ISS.

Due to budget and schedule constraints, the project adopted a protoflight development approach. In general, subsystems have breadboard, engineering model (EM) and flight model (FM), but no qualification model. A Structural Test Article is a flight-like enclosure in terms of mechanical form and fit, and is used to test and verify the random vibration loads using mass simulators for the SDRs, avionics card cage, RF subsystem, and Antenna Pointing System. In general, subsystems are verified to protoflight levels at the partner facilities prior to delivery to GRC for system-level integration, functional check-outs, and verification and validation (V&V) including environmental and communications testing.

1.4.2 Flight System Development Approach

GRC facilities and infrastructure are used for GRC subsystems and system integration and test. The mechanical system was manufactured largely in-house at GRC. Environmental testing of the flight system was performed using GRC facilities, including vibration testing, thermal vacuum testing, and EMI testing. Additionally, interface verification testing was accomplished at GRC via TDRSS and NEN compatibility testing, and ELC Simulator testing. Building 333 is utilized for the assembly, integration and test of the

[1] "SCaN Testbed" is the official ISS Operations Nomenclature (OPNOM) for the "flight system" or "payload," all three used interchangeably. CoNNeCT is the overall project name.

Flight System, GIU and other GSE/TSE. This facility will be used as the permanent location of the CoNNeCT Ground Systems during Phase E of the project.

1.4.3 Flight Software Development Approach

To facilitate development of the software, multiple Software Development System (SDSs) are built including flight-like avionics to enable testing of flight and ground software. One SDS is used for parallel software development, then used for an Experiment Development System (EDS). The EDS is used for waveform development and testing. A Ground Integration Unit (GIU) builds upon the SDS and adds more functionality including the SDR EM units, the Antenna Pointing System Brassboard unit, and other smaller components. Once completed, the GIU is an integrated flight-like system that enables flight and ground software (including command load) development and verification prior to the flight system. The normal flow of avionics software development and testing is from an SDS, to the GIU, then to the flight system. Likewise, the normal flow of waveform development and testing is from the EDS, to the GIU, to the flight system.

1.4.4 Mission Operations Approach

CoNNeCT mission operations utilize existing infrastructure at the Telescience Support Center (TSC) also located in GRC Bldg. 333. TSC is supplemented by CoNNeCT-unique ground systems to make up the CoNNeCT Control Center (CCC). The CCC is used for the on-orbit check-out and commissioning phase of the SCAN Testbed and the subsequent mission and experiment operations. The CoNNeCT Experiments Center (CEC) is located adjacent to the CCC, and allows Principal Investigators to review the results of their experiments and participate in the mission operations. Commands and data are initiated at the CCC and routed both through the standard ISS payload command path as well as directly to the flight system through the Space Network via TDRS satellites or the Near Earth (Ground) Network and finally to the CoNNeCT payload. Approval of the CoNNeCT operating frequencies is obtained from the Agency Spectrum Management Office, also located at GRC.

The GIU has regular use throughout the duration of the mission for SDR waveform vetting, testing of software changes, experiment check-out and validation prior to software upload to the payload, and for on-orbit anomaly troubleshooting.

1.4.5 ISS Integration Approach

The approach for analytical and physical integration with the ELC and the HTV carriers includes a coordinated set of activities worked through the JSC Payload Integration Manager (PIM). The project is provided an ExPA for structural mounting and interface services. The carrier physical interfaces are depicted in Figure 1-4. The analytical integration is completed through a series of documents including interface control documents and agreements, safety data packages, resource requirements, data sets, and final flight certification. On orbit, the SCAN Testbed is installed on ELC-3 located on the exterior truss of the ISS.

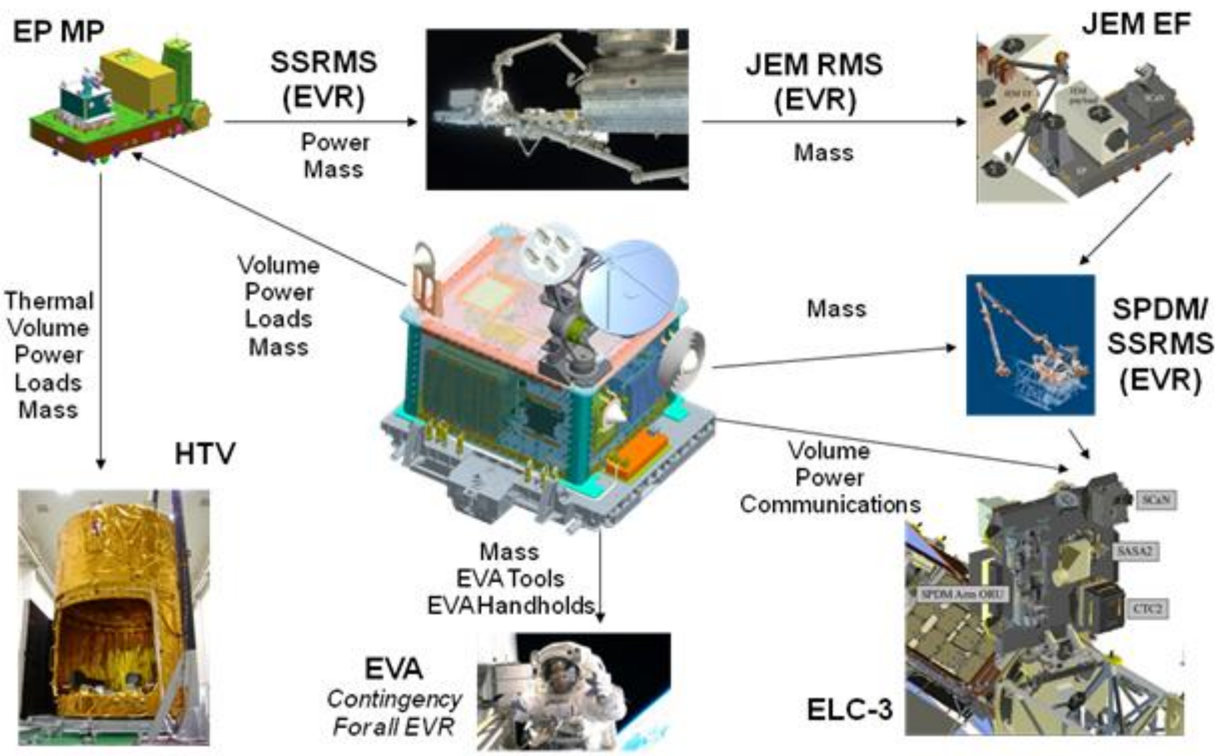


Figure 1-4—CoNNeCT Carrier Systems Interfaces

Ground integration and launch from Japan at the Tanegashima Space Center occurs at the JAXA facilities located at JAXA's Tanegashima Space Center, as depicted in Figure 1-5. These facilities are comparable in scope and capabilities to KSC pre-flight integration and test facilities.

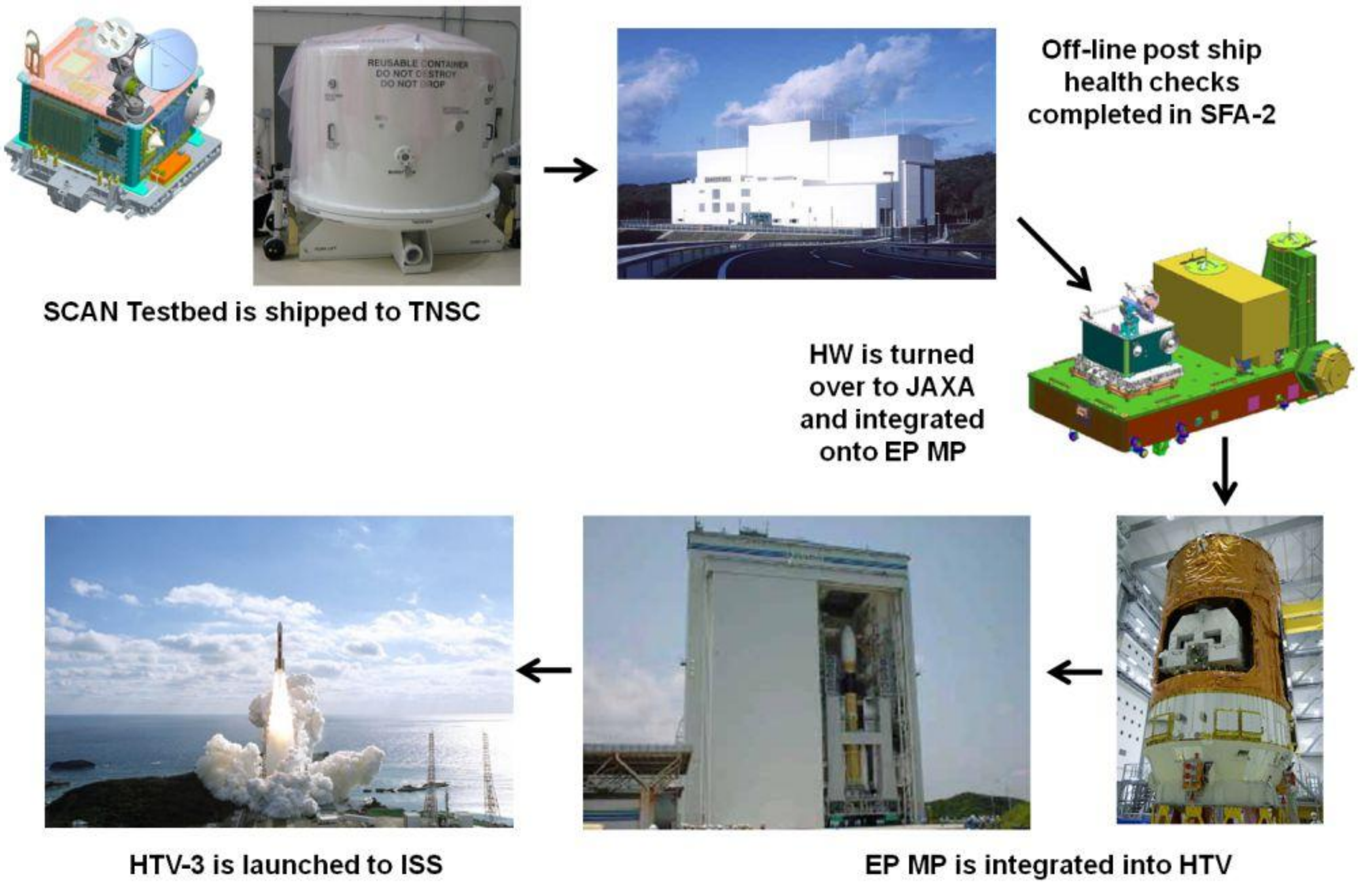


Figure 1-5—CoNNeCT Ground Processing at Tanegashima Space Center

1.4.6 Ground System Approach

The Ground System is comprised of many elements and will be used for software development, experiment development, mission operations, and sustaining engineering. The following are the key elements.

1.4.6.1 Experiment Development System (EDS)

The Experiment Development System (EDS) is comprised of a suite of breadboard fidelity equipment representative of the Flight System SDRs, as well as corresponding software development system (SDS), simulators, test support equipment, ground support equipment, data acquisition system, and corresponding physical and functional infrastructure. The EDS will host a variety of activities associated with experiment concept maturity as this will be the initial exposure to and interaction with ground asset capability for approved experiments.

1.4.6.2 Ground Integration Unit

The Ground Interface Unit (GIU) is a suite of engineering model fidelity equipment representative of the payload flight unit, and is interfaced to GSE to simulate ISS and Space and Near Earth Network interfaces. It is used for payload software development, experiment development, final verification of payload and experiment software prior to uploading to the Flight System, as well as mission operations support, such as procedure development and validation, training, and anomaly resolution. The GIU can be interfaced with the CCC to support mission operations preparations and execution as appropriate.

1.4.7 Utilization Approach

New waveforms, applications, and concepts, along with the use of the SCAN Testbed for validation of other systems, will be developed by both NASA Principal Investigators and external entities, such as other Government agencies, industry, and academia. A variety of outreach mechanisms will be employed to advertise the SCAN Testbed capability and solicit potential experiments such as websites, technical forums, Announcement of Opportunities, NASA Program and Resource Guidance (PRG), vendor cooperative agreements, and the Small Business Innovation Research program. The CoNNeCT Experiment Board (CEB) prioritizes and recommends experiment proposals for selection for all proposals other than those through the SBIR process. The SCaN Program Systems Planning Division is the governing body for all experiment and utilization of the SCAN Testbed, except for SBIR awards. For proposals submitted through the SBIR process, the CEB will provide members as reviewers for the SBIR award selection process to insure feasibility.

Selected proposals that are not NASA sponsored, except SBIRs, are approved via mutually signed agreement with the Project, such as a Space Act Agreement, to determine respective responsibilities, resource obligations, top-level schedule, data rights, patents, etc. Selected experiments that are NASA sponsored are approved via signed Task Agreements with the Project and the SCaN Systems Planning Division. The experimenter or user will develop an Experiment/Utilization Plan that indentifies specific details such as objectives, technical development, verification, and operational approach, required Project provided assets and/or skills, phased schedules with milestones and deliverables, and plans to manage the overall endeavor. Experiment liaisons will be assigned to assist the user in maturing the concept and developing requirements, such as flight and ground software upgrades, and utilization of SDSs, EDS, or GIU. Ground assets are utilized to develop approved concepts, and review gates are instituted during the development process. The requirements of NPR 7120.8 are utilized for the ground development. However, prior to upload to the SCAN Testbed on ISS, the matured concept will graduate to Flight Status, and its final verification activities will be consistent with NPR 7120.5. This life cycle of solicitation, development, integration, and operations is depicted in Fig 1-6.

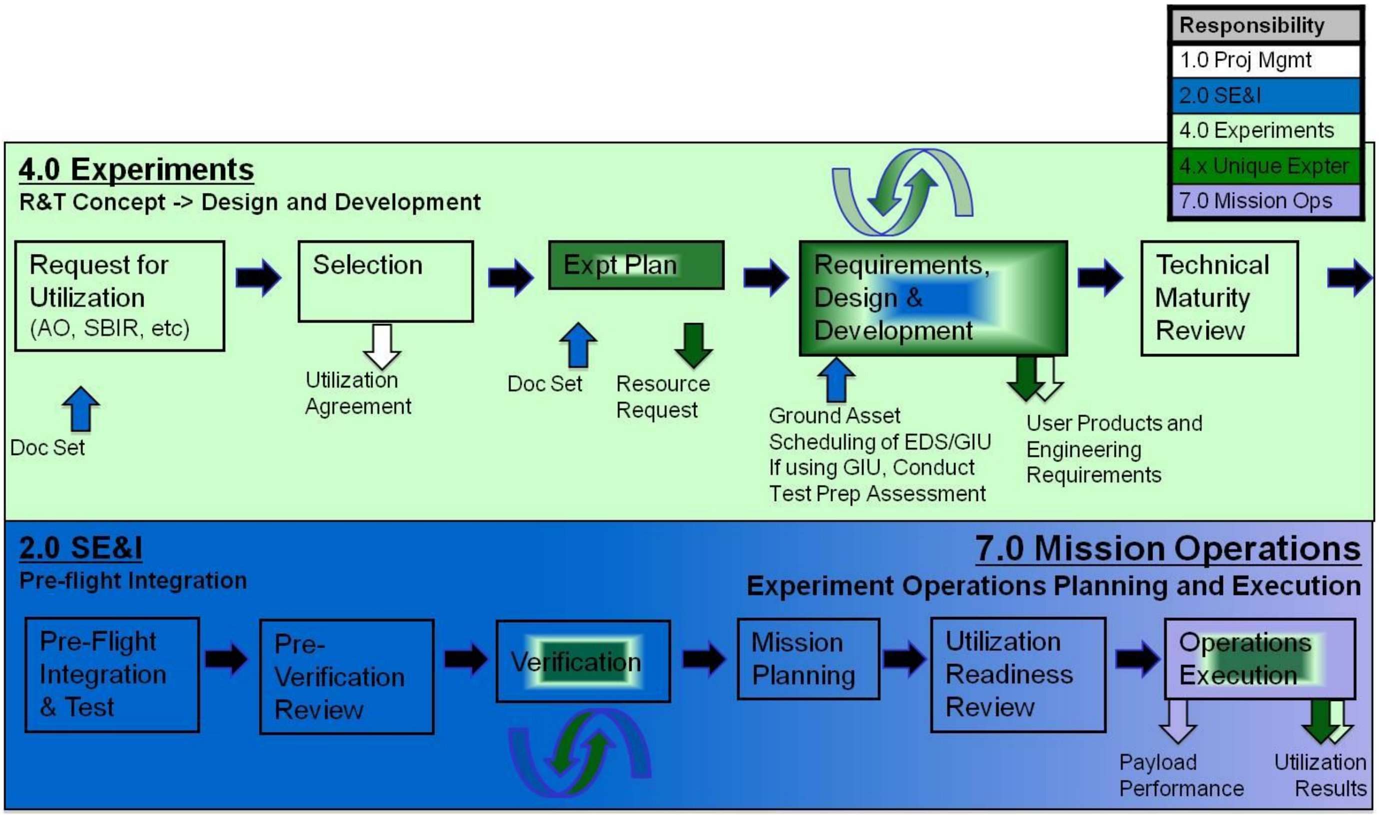


Figure 1-6—CoNNeCT Utilization Approach

In order to enable concepts not incorporated in legacy Space Network TDRS processing at the White Sands Complex (WSC) (e.g., new waveforms, higher order modulation techniques, higher data rates), a ground SDR unit will be designed, developed, and implemented within the capabilities of the on-orbit SCAN Testbed and correspondingly integrated with Space Network ground system. A field unit will be installed, integrated, and operational at WSC with a duplicate ground SDR at GRC as a ground asset that will allow users to test the experimental concept, waveform, etc as prior to operations with the actual SCAN Testbed.

2.0 AUTHORITY, GOVERNANCE, MANAGEMENT STRUCTURE, AND IMPLEMENTATION

The CoNNeCT project is managed by the Space Flight Systems Directorate (SFSD) of the NASA Glenn Research Center (GRC) as shown in Figure 2-1.

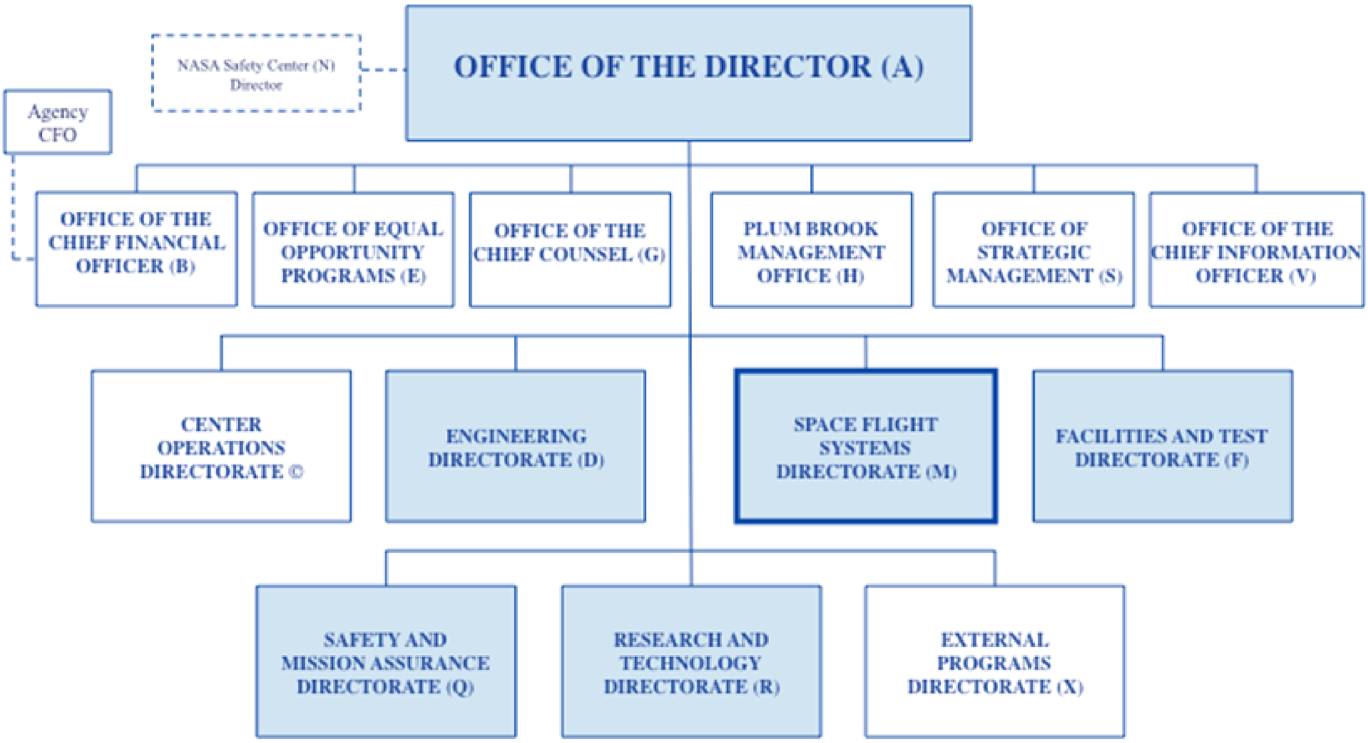


Figure 2-1—GRC CoNNeCT Organizations

The major organizations supporting CoNNeCT at GRC are shown in blue. The project management responsibility for the CoNNeCT project is assigned to the GRC Space Flight Systems. The CoNNeCT project manager at GRC manages the project in accordance with this plan and all applicable NASA policies and federal regulations.

Program Management is provided through the SCaN Program Office. The PM reports to the Director of the SCaN Program Office, Systems Planning Division, or designee, as illustrated in Figure 2-2. As Program Manager, final program Decision Authority (DA) resides with the SCaN Program Office. The SCaN Program Office performs Level I/II program functions and is the Project Customer. The SCaN Director of Systems Planning Division provides overall program scope and guidelines to the project and provides annual budget authorizations to sustain the approved plans.

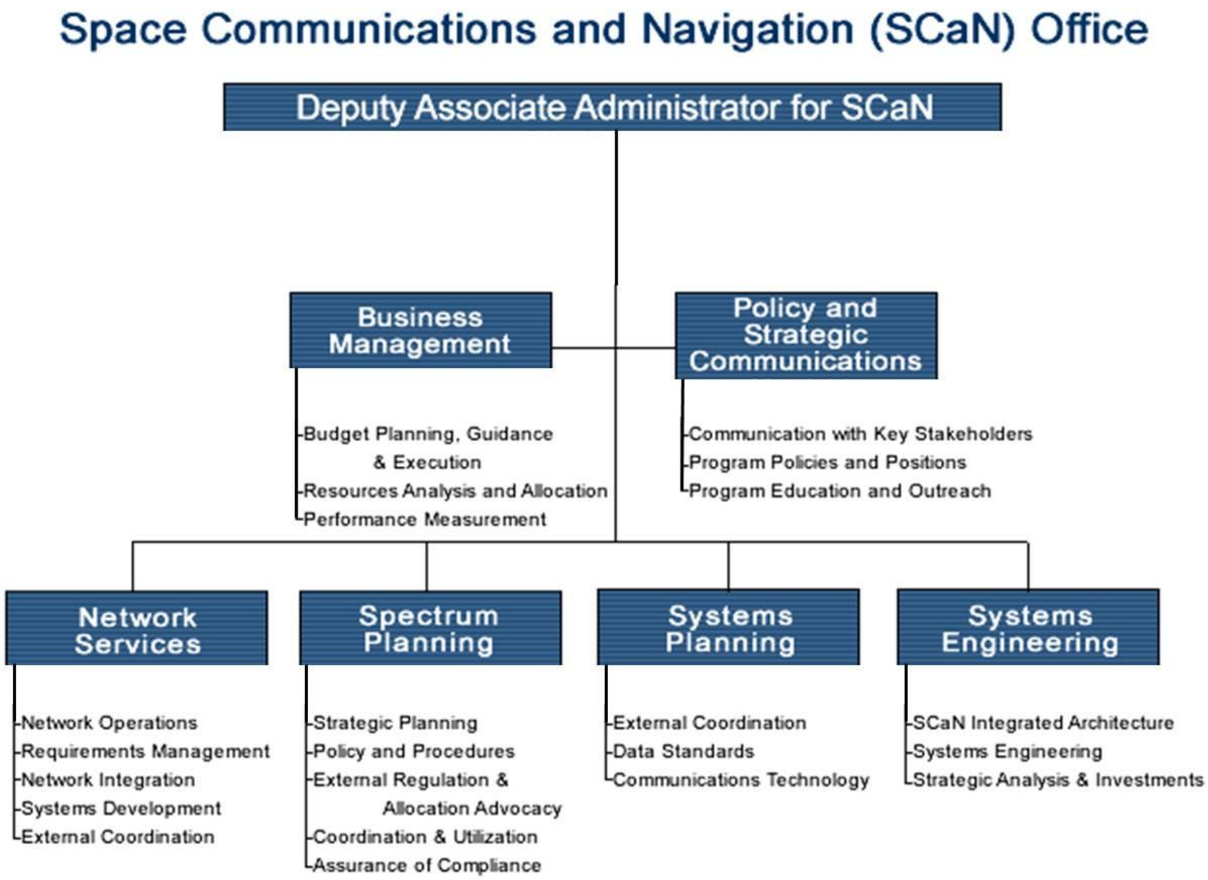


Figure 2-2—HQ SCaN - GRC CoNNeCT Project Organization

The project approval process determines readiness to proceed from the Formulation Phase to the Implementation Phase through the Authority to Proceed (ATP) process. Once approved, this Project Plan provides the baseline for implementation planning and execution. The signed project plan baseline serves as the commitment agreement between the project and the program.

2.1 Project Organizational Structure

The project is organized as a matrixed, product-based team with the organization reflecting key products delivered as well as necessary cross-cutting areas such as Systems Engineering and Integration, and S&MA. The project utilizes workforce skills, expertise, and competencies from various organizations at GRC as well as NASA partners. The project management team at GRC and the partner Centers work with the institutional line management to secure the required workforce and facilities to implement the project.

To effectively manage the work through Phase C/D, E, and F, the project top level organizational structure will continue to evolve over time. Specifically, the Experiment Comm WBS element has transitioned to assume responsibility for the development of SCAN Testbed Experiments. Additionally, once complete, the Software will transition into a sustaining engineering function within SE&I, and External Interfaces will migrate to Mission Operations. Figure 2-4 identifies the current Phase C/D organization and Figure 2-5 represents the Phase E Operations Phase of the project. This project organization aligns with the Project Work Breakdown Structure (WBS), hence roles and responsibilities are defined in the WBS Dictionary in Section 3.2 below.

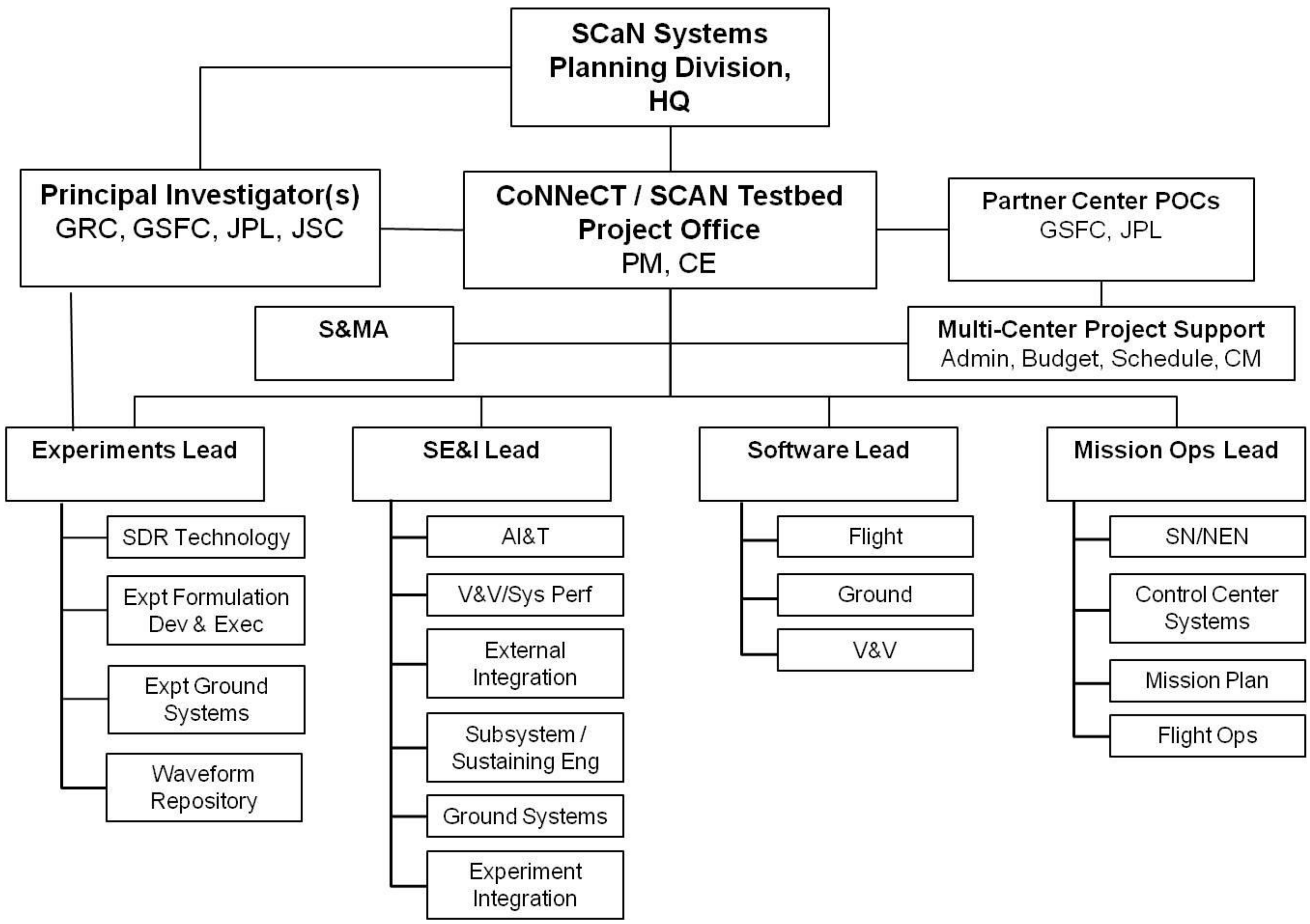


Figure 2-3—Phase C/D CoNNeCT Project Organization

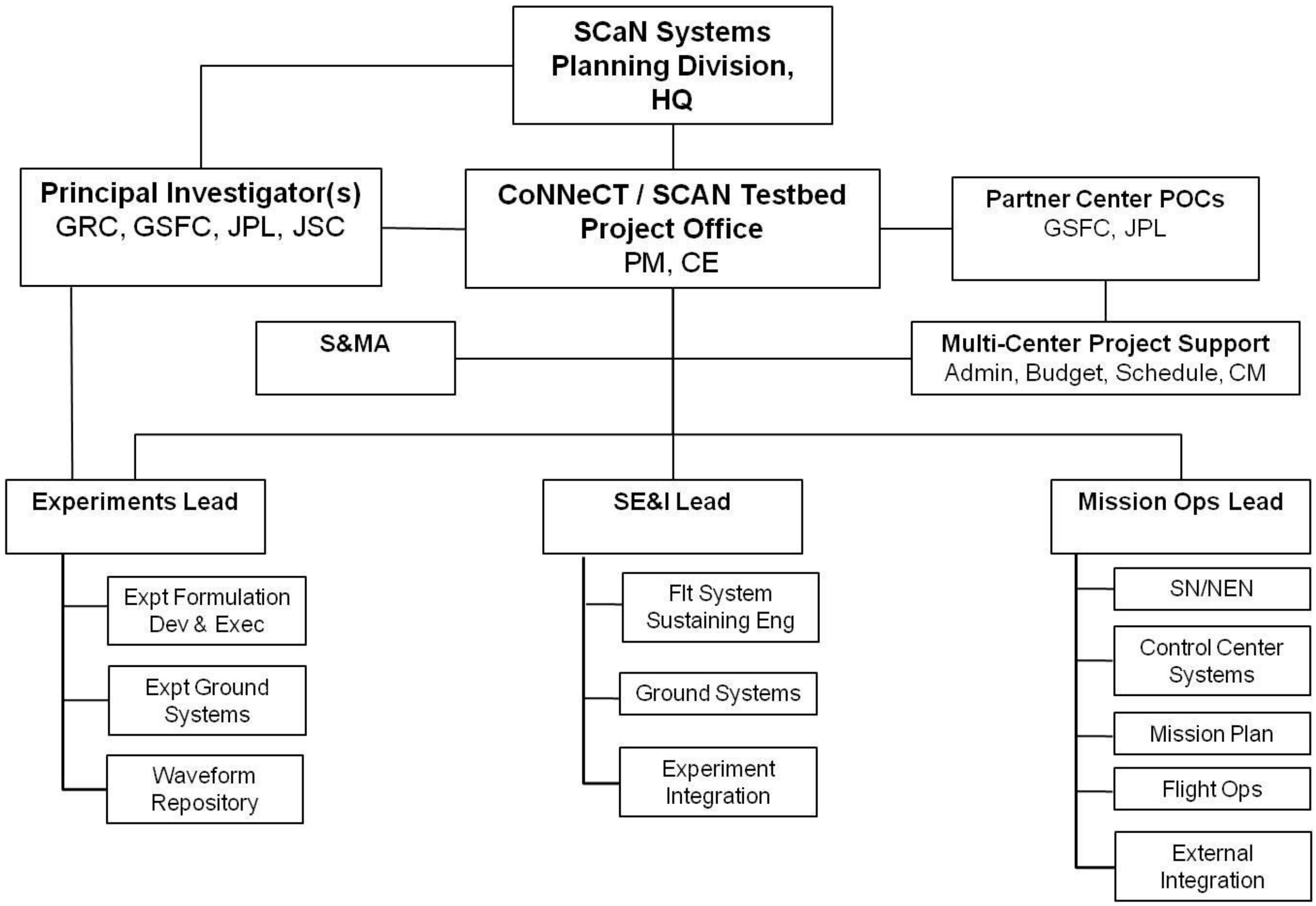


Figure 2-5—Phase E CoNNeCT Project Organization

The CoNNeCT project is a multi-center and industry development project with significant activities distributed amongst a number of major organizations. GRC, as the overall lead, conducts project integration and system-level verification, and validation, GRC developed the supporting mechanical, electrical and software infrastructure for controlling and data handling of the SDRs and associated interfaces with the ELC. As mentioned previously, the three SDRs were developed by JPL, GD, and Harris. Also mentioned above, several different organizations developed STRS-compliant waveforms and delivered them to GRC for pre-flight and flight loads on the radios. JPL also developed the RF sub-system and associated antennas for integration onto the payload.

GRC will lead the Experiments WBS, and demonstration elements within it. Co-Principal Investigators from GRC, JPL, and GSFC will oversee the experiment development activities at their respective Centers, consistent with the CoNNeCT Research and Technology Management Plan, GRC-CONN-PLAN-0857.

GRC also develops the associated ground support infrastructure with support from GSFC, to enable the CCC to be located at GRC and provide the associated connectivity over the necessary space and ground networks for data dissemination to and from the on-orbit payload. JSC is the project interface for ISS integration and operations and launch vehicle integration with a Payload Integration Manager assigned to support CoNNeCT. As part of ISS integration, JSC supports the project with ISS radiofrequency (RF) compatibility analyses and RF frequency application and allocation for operations as an ISS payload with connectivity to the Space Network (SN) and Near Earth Network (NEN). Project partnerships are secured via Task Agreements (TA's) with JPL, GSFC and JSC and Cooperative Agreements (CAs) with industry partners GD and Harris, as approved by the PM.

2.2 Governance

Governance of the project utilizes the key roles of the Project Manager (PM), the Principal Investigator (PI)/Project Scientist (PS) and the Chief Engineer (CE) for successful project management and implementation. Through continuous interaction between the PM, the PI and CE, the project considers all aspects critical to the project's success. The PI represents the overall mission objectives and requirements of the project, and is responsible to unsure the Experiments program meets the long term objectives of the project. The PI is also performing a "down and in" PS function in which the communications technology and communications systems engineering function and products are informing the flight design. The CE represents the technical implementation of the project through technical excellence as the project progresses from planning, to development and flight, and mission operations. The CE also represents the Engineering Technical Authority. The Chief Safety Officer for CoNNeCT (not shown in organization chart) represents the Safety and Mission Assurance Technical Authority. The PM is the final authority on all project matters such as technical, resource and schedule performance and management of project risks.

As a Category III project per 7120.5D, the governing council for the project is the GRC Center Management Council (CMC). The CMC responsibilities include project oversight, and review and approval of project programmatic waivers from 7120.5D. The CMC may delegate certain functions to the GRC Space Flight Systems (SFS) Directorate Project Review Board PRB such as the convening of project independent review boards, and review and approval of project review responses and plans (such as Request for Action (RFA) and/or Review Item Discrepancy (RID) disposition plans). The CMC also evaluates and approves project Key Decision Points (KDPs). Final decisions on KDPs are made by the SCaN Program Decision Authority (DA) for CoNNeCT, which is the DAA for SCaN.

2.3 Engineering and S&MA Technical Authority

The CoNNeCT Project Manager has overall programmatic authority, responsibility and accountability for the execution and success of the project. In the majority of situations, it is expected the project manager agrees with the technical guidance and recommendations of the Chief Engineer (CE) and the implementing technical organizations across the agency supporting the project. Resolution of disputed technical issues (issues where the PM does not accept the recommendation of the CE) follows the technical authority process described herein.

The CoNNeCT Chief Engineer is organizationally separate from the line organizations responsible for the achievement of project objectives. The current organizational architecture of the Glenn Research Center maintains separate lines (between the Technical Authority and the program/project management) up to the Office of the Center Director. CoNNeCT technical issues or dissenting opinions can be raised to the CoNNeCT Chief Engineer by any requesting individual. The CE utilizes the Engineering Management Board (EMB) to review and baseline key technical elements of the project. Likewise, the CSO utilizes the S&MA Management Board (SMB) to review and baseline key elements for Safety and Mission Assurance. The CE or CSO may also utilize the EMB/SMB to help resolve technical issues. If necessary (and very rarely), issues can be raised up to the Center Director whenever an impasse is reached between decision choices, or when there continues to be a disagreement between the PM and the TA.

2.4 Board Charters Roles and Responsibilities

The CoNNeCT Project includes five control boards and the charters are contained in Appendix C and more details are as follows:

1. CoNNeCT Control Board (CCB) for overall project control and Configuration Management decisions
2. Risk Review Board (RRB) for validation and management of project risks
3. Engineering Review Board (ERB) for review and decisions on technical items
4. Anomaly Resolution Board (ARB) for review and disposition of hardware and software anomalies
5. CoNNeCT Experiment Board (CEB)

In the period after the SAR, the CCB performs the function of the RRB.

2.5 CoNNeCT Control Board (CCB)

The CoNNeCT Control Board (CCB) is a decision-making body that approves and controls the baseline of the project, is a forum for general project items, and performs the configuration management and control. The CCB is chaired by the PM and, as a minimum, have as members the project Chief Engineer (CE), and the Principal Investigator (PI). . The CE recommends appropriate technical expertise and the CCB may include the Lead Systems Engineer, the Software Engineer Lead, S&MA, and other Engineers relevant to the CCB content under review. The PM, or the PM's alternate, the DPM, is the final authority for all decisions for the CCB. At the discretion of the PM, supporting Centers may be invited to the CCB.

Contractor Configuration Control Board Activities: Each contractor design activity shall have their own configuration control boards that shall be responsible for establishing an internal baseline and controlling changes thereto. CoNNeCT Project personnel engage with contractors on any items impacting end item deliverables and the associated cost and schedule. Contractor proposed changes to the CoNNeCT baseline must be worked through the COTR and brought to the CCB for approval.

2.6 Risk Review Board (RRB)

The RRB is a decision-making body that validates or rejects candidate internal and external risks, and, reviews and tracks validated risks to closure. The project Risk Facilitator Lead facilitates the RRB and maintains the risk database, called the Risk Management Implementation Tool (RMIT). The RRB is chaired by the PM (or DPM) and includes the CE, and S&MA. Other members may be included as appropriate, such as WBS Leads, PI/PS, Risk Originator. The Project Manager is the ultimate authority on risks. The Project Manager decides on the subset of risks to be elevated as "Top Project Risks" and also controls the resources expended to mitigate risks, based on input from the RRB.

Contractor RRB Activities: Each contractor shall have their own risk management process. CoNNeCT personnel evaluate significant contractor risks and enter candidate risks in the CoNNeCT risk system for risks that impact that subsystem or system (e.g. SRD delivery date).

2.7 Engineering Review Board (ERB)

The CoNNeCT Engineering Review Board (ERB) will review technical aspects of the project, make decisions on technical items not impacting cost or schedule, and provide recommendations to the CoNNeCT Control Board (CCB) for technical items that do impact cost and schedule. The ERB is chaired by the CE and members include the project WBS Leads and Discipline Lead Engineers (DLEs) and other Subject Matter Experts (SMEs) as necessary depending on the review topic. Its functions are to review and resolve major engineering issues, review Problem Reports, and serve as a Pre-Board and provide recommendations to the CCB for final project disposition. The ERB also includes content associated with external suppliers brought to the ERB by the cognizant WBS Lead.

2.8 Anomaly Resolution Board (ARB)

The Anomaly Resolution Board (ARB) is a decision-making body that reviews anomalies of the Flight System and Ground System. The ARB is chaired by the Deputy Project Manager and the membership includes Chief Engineer, SE&I Lead, S&MA, and other cognizant engineers, as necessary.

A Corrective and Preventive Action Report (CPAR) will be filed by the person that first encounters the anomaly. The ARB will determine the CPAR disposition and the assignee for Corrective Action. The ARB employs the use of Responsible Managers (RMs) in the CPAR System (CPARS) that have the authority to assign and disposition the CPARs. After the corrective action has been implemented and verified by the RM, the RM forwards the CPAR to the PM for closure. Final close out of CPARs are done by S&MA

Software non-conformances are defined as problems related to formal software V&V. Routine bug tracking will be done outside of the ARB process and be documented in a database managed by the Software Team.

2.9 CoNNeCT Experiment Board (CEB)

The CEB is chartered as the decision-making body that will review, select, prioritize, and manage conflicts among multiple experiments, consistent with the project Level 1 requirements, GRC-CONN-REQ-0019, and Mission Success Criteria, GRC-CONN-RPT-0099. Experiments selected by the board are recommended to the Director of Systems Planning for approval. This board is responsible for the successful implementation of the CoNNeCT Technology and Research Management Plan, GRC-CONN-PLN-0857. It is chaired by the PI and membership consists of the PI, Deputy PI, Co-PIs, and the SCaN Systems Planning Division Representative. The Experiment Lead, the Mission Operations Lead, and SE&I Lead, and other subject matter experts from across the Agency representative and knowledgeable in the CoNNeCT technologies, or future mission applications of the technologies, may also be invited to participate as necessary. Technical, budget, and schedule impacts to the overall project will accompany the CEB recommendations to the Director of Systems Planning.

2.10 Other Project Meetings

The project also holds regular CoNNeCT Schedule Meetings, led by PM and supported by CE, PI, and other technical leads. Depending on the topic, technical leads may invite our NASA and non-NASA partners to support the technical discussion including JPL, GSFC, JSC, Harris, and GD. Project Schedule modifications are decided in this forum.

The project holds regular status meetings led by the Project Manager and supported by the WBS leads and other personnel as required. The purpose of these meetings is to cover general technical, cost, schedule, and risk status and to plan for upcoming events and action closure.

The project leadership (PM, DPM, CE, DCE, and PI) meets regularly to coordinate leadership aspects of the project, and may include the SE&I, and S&MA as needed. These leadership coordination meetings enable the leadership team to be more consistent, establish priorities, discuss issues and concerns, make sure critical activities are covered (roles for each member), and to assess future events, especially those requiring careful management.

2.11 Stakeholder Definition

Key stakeholders for the project include the HEOMD and the SCaN program office, the STRS architecture developers, the SDR and waveform technology developers within the private and public sectors, the CoNNeCT partners at GRC, GSFC, JPL, and JSC, as well as other NASA mission directorates such as ESMD and Science. The Department of Defense (DoD) is also a stakeholder given SDR technology is of high interest for their ground missions such as the Joint Tactical Radio System (JTRS), and for their space based applications. Stakeholder advocacy is maintained through regular project reviews, forums, and other venues. Experimental data resulting from CoNNeCT experiments will be disseminated to the greatest extent possible through technical conferences, papers, and symposiums. CoNNeCT mission application demonstrations and evaluations such as the Lunar Relay emulation are planned and executed in close coordination with relevant mission planners, and the results communicated through appropriate mission relevant forums to maintain stakeholder awareness and engagement.

3.0 PROJECT BASELINE

3.1 Requirements Baseline

Key project requirements are defined in the CoNNeCT Level I Requirements (CONN-REQ-0019), as decomposed to the Level II Systems Requirements Document (CONN-REQ-0035), and further decomposed to Levels III and IV. The Level I requirements from the SCaN Program Office, the science and technology requirements from the PI, carrier requirements from ISS and JAXA, SN and NEN capabilities and requirements, and safety requirements are all key driving requirements for the project. All requirements sources for the project are defined in the CoNNeCT Systems Engineering Management Plan (SEMP) (GRC-CONN-PLAN-0005).

The driving requirements and architecture for CoNNeCT is shown in Table 3-1.

Table 3-1—CoNNeCT Driving Requirements and Architecture

Level 1 Driving Requirements	CoNNeCT Architecture & Processes
Lunar Relay Emulation - High rate at Ka-band	System capable of 25 Mbps and up to 100 Mbps
Lunar Relay Emulation - Multi-band, multi-link transceiver operation	Asymmetric data rates using both S-band and Ka-band simultaneously
Network routing capability	Network routing capability available in avionics
Ka and S-band 2-way TDRSS Communications at specified data rates	One (1) Ka/S-band SDR & two (2) S-band SDRs
STRS compliance	STRS platforms and waveforms compliant to STRS Rel 1.02
Multiple SDRs on payload	Three (3) SDRs
Operational Concepts Demonstrations & Risk Reduction Experiments – GPS, DTN, C3I	Capable SDRs Reconfigurable SDR capability available for Experiments
SDR Reconfiguration - Advance SDR and STRS Standard & Technology	Reconfigurable SDRs and waveforms compliant to STRS
High Reliability and Availability (Project shall address Single Point Failures that could render whole payload inoperable or otherwise seek waivers)	Per HQ agreement, elaborate SPF mitigation is beyond current project baseline and would require project impact assessment on additional cost, schedule. However, robust design and development practices employed to ensure high reliability.
Class D payload, near two (2) year life	Robust Design for 2+ year life
FHA date of February, 2011	Development schedule turn-over to JAXA at L-5.5 months
Utilize ELC carrier/integration on ISS	Space environment, ELC installation/operation/manned safety
Launch time frame and payload size require HTV launch	HII-B/HTV drives size, mass, launch & keep-alive environment
P3 ISS location for visibility/access	P3 drives multi-path, antenna locations and RAM facing

3.2 Work Breakdown Baseline

The CoNNeCT Project Work Breakdown Structure (WBS) maps to the organizational structure in general; however, it also includes a more detailed decomposition to enable technical, schedule and cost planning. The work breakdown for the CoNNeCT project is separated into seven different product-oriented tasks, with project-optimized tailoring from NPR 7120.5D as listed in Table 3-2. In terms of the NASA financial system, this WBS begins in FY10 under 553223. It should be noted the historical financial WBS was 439432 in FY08 and moved to 553223 for the post-SRR WBS starting in mid FY09.

Table 3-2—CoNNeCT WBS Mapping to NPR 7120.5

CoNNeCT WBS	NPR 7120.5 WBS
1.0 Project Management	Same
2.0 Systems Engineering and Integration	Same
3.0 Safety and Mission Assurance	Same
4.0 Experiments	4.0 Science and Technology and Comm Systems part of 2.0 SE&I
5.0 Flight System (No longer used)	5.0 Payloads and 6.0 Spacecraft
6.0 Software	6.0 Spacecraft (Avionics Software subsystem)
7.0 Mission Operations	7.0 Mission Operations
2.5 External Integration	8.0 Launch Vehicle/Services
5.8 Ground Systems, 6.3 Ground S/W, 7.3 Control Center	9.0 Ground Systems
2.4 Assembly, Integration and Test,	10.0 Systems Integration and Testing
1.4 Education and Public Outreach	11.0 Education and Public Outreach

The two-digit WBS dictionary that describes the work products and roles and responsibilities is included in Table 3-3.

Table 3-3—CoNNeCT WBS Dictionary

WBS #	Title	WBS Dictionary
1.0	**CoNNeCT Project Management**	This WBS element includes the effort for project planning, acquisition management, organizing, directing, coordinating, controlling, and approval processes used to accomplish the overall CoNNeCT Project and Mission Success objectives.
1.1	Project Management	This element includes comprehensive Project budget development and detailed cost phasing, including support of PPBE calls. This includes all project management tasks as executed by the PM, the Deputy PM, Project Principal Investigator, and Co-Principal Investigators and POCs at the partner Centers GSFC and JPL. PM/DPM responsibilities include the overall management of project technical content, budget, schedule, and risk. This element also includes project duties for agreement negotiation and commitment of project resources to execute SCAN Testbed development and utilization endeavors as well as lessons learned, project reviews, status reporting, and documentation. Project Principal Investigator and Co-Principal Investigator responsibilities include management of the research & technology aspects of the SCAN Testbed including mission success criteria evaluation, sponsoring and conducting Announcements of Opportunity, insuring a balanced utilization portfolio, and assessing results for future NASA mission infusion. Project Management and Project Principal Investigator obligations are fulfilled to the SCAN Program Office, the GRC Spaceflight Systems Directorate, and the GRC Research & Technology Directorate within this WBS.

WBS #	Title	WBS Dictionary
1.2	Business Management	This element includes overall multi-center project resource planning and development, including detailed program cost phasing, support of Planning Programming Budget and Execution (PPBE) calls, variance analysis, distribution of funding authority, and resource loading for contractor personnel. In addition, this element has project Agency-wide resources oversight across partner centers, provides coordination across Centers during PPBE, provides narrative instructions to Headquarters for the guideline document, and works directly with the SCaN Program Business Manager to allocate and issue funding to the CoNNeCT partners. Overall management of resources includes: development of budget baselines, preparation of FY Operating marks to Centers, validation of the financial WBS structure with Headquarters, issuing guidelines and policies, and budget formulation, analysis and reporting.
1.3	Configuration Management	This element includes all subcontracts, labor, material, and other direct costs for configuration control consistent with NPR 7123.1. Includes drawings, specifications, documentation and hardware and software configurations. Includes data management tools & services for all engineering design, data, and parts information generated. Maintains data and information according to GRC product data management processes and practices; provide necessary indexing, referencing, storage, and retrieval functions via a networked environment that provides access by personnel. Assure compliance with ISO 9001, NPR 7120.5D, ITAR, EAR, etc. Includes Project and Risk control boards official documentation.
1.4	Education and Public Outreach	This element includes targeted activities to educate the general public and engineering and scientific communities. E&PO efforts include general outreach associated with SCAN Testbed as a technology platform as well as the science and technology outreach from the ground and mission operations. Content includes web articles, brochures, technical conference papers, and STEM education products. GRC and partner Centers contribute to this area as resources allow.

WBS #	Title	WBS Dictionary
2.0	**CoNNeCT Systems Engineering & Integration**	This element includes the technical and management efforts of directing and controlling an integrated engineering effort for the payload and ground systems development, experiment and utilization integration, and corresponding sustaining engineering. This element includes the efforts to integrate and test the project space flight unit and ground system including performing verifications, conducting integration with the carriers, and defining on-orbit installation and decommissioning activities/reviews. Documentation products/updates include requirements documents, milestone review plans, System Engineering Management Plan, hardware description documents, experiment integration process documents, interface control documents (ICDs), and master verification and validation (V&V) plan.
2.1	Systems Engineering Management	This element includes all labor, subcontracts, materials and other direct costs to manage the systems engineering process and personnel necessary to support the mission. This element oversees all other systems engineering WBS elements and manages resources needed to accomplish the identified tasks. Responsible for system level milestone reviews and overall compliance with NPR 7123.1 and lead anomaly resolution activities as the project's overall Comm Systems Engineer.
2.3	Flight System Assembly, Integration & Test	This element provides for the planning, coordination and execution of system-level assembly, integration and testing of CoNNeCT Flight System hardware. Prior to ship, all day to day activities involving the flight hardware are managed and facilitated by the AI&T group.
2.4	System Verification & Validation / System Performance	This element determines whether the product or system and software fulfill all the design solution specifications and descriptive documents and whether the product accomplishes the intended purpose based on stakeholder expectations. Compliance is determined by a combination of test, analysis, demonstration, and inspection. System performance assesses and tracks the performance characteristics of the system through the life of the Project. This element is also responsible for developing and maintaining the requirements documents, FDIR, availability analysis and modes and states document.

WBS #	Title	WBS Dictionary
2.6	External Integration	This element insures processing of the flight system from originating site through transport for carrier installation, launch vehicle integration and launch, transportation to ISS, installation onto ISS ELC site, and ISS engineering integration activities during ISS operations. Ensures all activities associated with securing ISS Carrier transport for the CoNNeCT payload and all activities associated with securing CoNNeCT on launch vehicle manifest (currently targeting the HTV 3) are successfully accomplished per agreed schedule. Works with appropriate POCs at JSC, JAXA and other organizations to ensure payload is accommodated.
2.7	Flight System: Subsystem / Sustaining Engineering	This element provides necessary subsystem expertise in Mechanical/Thermal, Avionics, RF, SDR, and APS in order to complete sustaining engineering and anomaly resolution functions for the Project. Collaborates and consults with Mission Operations to solve on-orbit performance issues, and will work with Experiment Integration to assist users with developing experiment unique software or understanding SCAN Testbed subsystem functionality. Will include SW sustaining engineering activities at the conclusion of SW development.
2.8	Ground Systems	This element includes all of the resources required to complete the assembly, integration, test, operation and maintenance and sustaining engineering activities for the Ground System, excluding Control Center equipment and experiment-unique equipment. This element is responsible for Ground System equipment, including but not limited to, the Experiment Development Systems, Software Development Systems, Ground Integration Unit, TDRS Simulators, and other ground support equipment and test equipment. This element is responsible for the overall usage coordination and scheduling of these ground assets, as well as corresponding certification and documentation.

WBS #	Title	WBS Dictionary
2.9	Experiment Integration	This element includes all of the resources required to plan for and execute the integration of unique experiments and users into the SCAN Testbed. This WBS provides liaisons and/or subject matter experts to potential experimenters to technically educate, and prepare potential users to become an approved SCAN Testbed user, exercise the grounds systems for development, test, and verification, and execute experiment operations or other utilization endeavors. This element includes the development and maintenance of Project provided documentation to prospective and approved users, as well as any user-specific plans, requirements, and schedule imposed upon the Project to conduct a particular experiment or utilization activity set such as development and test efforts, readiness reviews, software compliance and associated verifications, procedure development and training, and corresponding data/results assessments.
3.0	**CoNNeCT S&MA**	Includes all subcontracts, labor, material, and other direct costs for establishing and maintaining a mission level Safety and Quality Assurance Program. This includes Safety Data Package prep and reviews, reliability analyses, monitoring EEE part alerts, coupon testing, defective parts analysis, monitoring subcontractor and partner Quality Assurance Programs and the cost of maintaining a failure review board.
3.1	S&MA Management	Includes all labor, subcontracts, materials and other direct costs to manage the S&MA process and personnel necessary to support the mission.

WBS #	Title	WBS Dictionary
3.2	Product Assurance & System Safety	The Product Assurance Plan (PAP) addresses all sections of the GRC SARG. The PAP documents how the project is going to meet the requirements of the SARG. Includes the cost of reviewing and monitoring subcontractor and partner QA reports, on-site inspections, and CPARS reporting system database management for CoNNeCT. Includes flight and ground safety data packages and reviews. Includes system reliability, availability, and maintainability. Includes all subcontracts, labor, material, and other direct costs for a mission level Failure Modes Effects Analysis and Single Point Failure Analysis to establish the probability of meeting mission requirements. Includes all subcontracts, labor, material, and other direct costs for implementing an independent software quality assurance program and to provide for an Independent Validation and Verification program of the flight software. Includes all subcontracts, labor, material, and other direct costs for establishing, maintaining and monitoring the Materials and Processes Control Program at the mission level. This includes establishing selection criteria for EEE parts, material manufacturing process guidelines, and monitoring subcontractor and partner compliance to the control program.
4.0	**CoNNeCT Experiments**	This element provides the overall science objectives, science requirements, and science and experiment aspects of the payload. This element monitors the system development to ensure that science requirements will be met by the concept, subsequent design, and operations. The element is responsible for the development and implementation of individual experiments and users of the SCAN Testbed.
4.1	Experiment Comm System Management	This element includes all labor, subcontracts, materials and other direct costs to manage the Experiments WBS and personnel necessary to support the mission objectives.

WBS #	Title	WBS Dictionary
4.2	SDR Technology	This element is responsible for the SDR functional and operational knowledge, including the ability to enable future experiments, development of new software and firmware, compliance with STRS standards, and ground and flight SDR characterization and performance assessments. This element also provides subject matter experts on each SCAN Testbed SDR, waveform development, implementation, and operation including any TDRSS services (e.g. ranging, timing) supported by the waveform. This element provides Project generated data for experimenters/users, SDR specific documentation, and waveform application development kits.
4.3	Experiment Development	This element is responsible for the development and execution of unique experiments that utilize the CoNNeCT Flight and Ground System to meet the mission objectives of the project. This element manages any SBIR or other SCAN funded contracts and grants for the development of experiments.
4.4	Experiment Ground Systems	This element is responsible for the development and operation of experiment specific ground equipment, such as the Experiment Front End Processor (EFEP), and performs experiment data management, and applications development and porting with the Ground SDR capability (field unit at White Sands Complex part of WBS 7.3).
4.5	CoNNeCT Waveform Repository	This element contains the repository of all waveforms affiliated with the use of the SCAN Testbed and/or developed and matured with its ground systems. This includes the determination of code, models, documentation, and repository templates for any waveforms or application software. Also, this element is responsible for the software release process/mechanism to other developers considering proprietary and ITAR protections. This element is responsible for the creation and maintenance of a CoNNeCT repository environment as well as the population, housekeeping, and dissemination of its contents, including interaction with the STRS standards repository as appropriate.

WBS #	Title	WBS Dictionary
6.0	**CoNNeCT Software**	This element develops and maintains the software for the Flight System, Ground System and related testing of the CoNNeCT Flight or Ground Systems, as defined in the CoNNeCT Software Requirements Document. This includes the software needed to test the flight or ground systems. This element excludes software development by any experiment team and will transition to 2.7 Flight System Sustaining Engineering at the conclusion of Payload SW development. **Note:** In the financial WBS, Software is listed in WBS 12.0.
6.1	Software Management	This element includes all labor, subcontracts, materials and other direct costs to manage the Software WBS and personnel necessary to support the mission.
6.2	Flight Software	This element covers all of the resources required to design, build, integrate and test the avionics flight software. The element covers the cost of the operating system and tools required.
6.3	Ground Software	This element is responsible for the design, development, integration and test of all software products to be utilized in the CoNNeCT Control Center (CCC) that communicate with the flight system, the CCC operators and any of the TSC.
6.4	Verification and Validation	The element is responsible for the V & V of the flight and ground software, and demonstrating compliance to requirements and stakeholders expectations.
7.0	**CoNNeCT Mission Operations**	This element is responsible for the overall coordination and implementation of all activities required to operate the CoNNeCT payload on the International Space Station (ISS), and conduct experiments through ISS, the Space Network (TDRSS) and the Ground Network stations at the Wallops Flight Facility. The Mission Operations lead will interface with WBS sub-element leads, serving as the lead coordinator for payload communications, data interfaces definition and implementation, and execution of SCAN Testbed decommissioning.

WBS #	Title	WBS Dictionary
7.1	Mission Operations Management	This element includes all labor, subcontracts, materials and other direct costs to manage the Mission Operations WBS and personnel necessary to support the mission. This includes coordination with the PI & WBS leads to assure compatibility, development of plans and procedures to be used during flight experiment operations, and training of personnel to staff the CoNNeCT Control Center in support of the execution of pre-flight mission simulations, off-nominal operations, anomaly resolutions, actual flight operations, and eventual decommissioning.
7.2	Space and Near Earth Networks	This element is responsible for conceptualizing, coordinating, and securing all CoNNeCT-unique ground network hardware/facilities/functions and coordinating TDRSS access and operations requirements associated with CoNNeCT space network experiments. The lead shall work with relevant organizations such as White Sands and NASA GSFC for TDRSS, the Wallops Flight Facility, the CoNNeCT Control Center lead, and any other relevant facilities.
7.3	Control Center Systems	This element is responsible for acquiring, establishing, maintaining and operating the hardware and software systems required for CoNNeCT command and telemetry processing, experiment execution, experiment data archiving and housekeeping data archiving. Computer hardware for primary and backup systems will be procured under this WBS element. The WBS element is responsible for the development, integration, operations and sustaining engineering of the SCAN Testbed Front End Processors, the Control Center TReKs, the White Sands SDR, and the integration of the Experiment Front End Processors into the TSC. This WBS element will also work with the Software WBS to assure that CCC ground software is verified and validated before flight. This element will also be responsible for integration and test of the CCC functionality with the GIU. This element will also work with the TSC and the Payload Operation Integration Center at NASA MSFC to assure compatibility of the CCC with the TSC systems and the MSFC Huntsville Operations Support Center (HOSC). The WBS lead will work with the TSC to develop and maintain a CCC/TSCICD. This element will also develop user guides and training manuals for the CCC and will train operators in its usage.

WBS #	Title	WBS Dictionary
7.4	Mission Planning	This element insures CoNNeCT communications are successfully planned, coordinated and implemented with the Space Network, Near Earth Network, and POIC. This element is responsible for generating the long range experiment timeline and refining that into the near term planning timeline, which culminates in the week of execution. This element is the point of contact for the ISS Pointers at JSC, the NEN Scheduling Officer, the Space Network schedulers, and the POIC planners. This element is also responsible for all POIC planning and submittals that must be done for each new increment SCAN Testbed is in operation.
7.5	Flight Operations	This element ensures all planning, coordination, and operations execution is performed to ensure CoNNeCT mission on-orbit operations are successfully accomplished. Operations shall be the primary interface with ISS Payload operations at the MSFC HOSC, and will coordinate extensively with Experiment Operations and Payload Health & Maintenance. This element is also responsible for ensuring that the CoNNeCT payload is controlled, maintained and monitored while on-orbit in support of mission operations/experiments. This element will execute payload commands during operations, and perform payload anomaly resolution. The lead shall work closely with the Mission Operations lead and the Experiment Lead to assure that all experiments are verified and validated on the GIU before being uplinked to, and executed on the flight system. This element is also responsible to interface with project configuration control to develop and implement a log and reporting system for the SCAN Testbed Flight Operations.

3.3 Schedule Baseline

As described in the overall approach, the CoNNeCT Project was formulated and built upon the foundation of the science required including the three software defined radios and other communications equipment. The key drivers for the project schedule have included the hardware subsystem maturity, software and waveform subsystem maturity, system assembly, integration & test, and the verification and validation of the flight and ground systems. These drivers and their logical relationships were diligently tracked through completion of those tasks. During the development, testing and integration activities the project was evaluated through independent reviews, in a process that was streamlined compared to NPR 7123.1 to four key reviews including: Preliminary Design Review (PDR), Critical Design Review (CDR), Test Readiness Reviews (TRRs) and System Acceptance Review (SAR). Other reviews were either combined with these reviews or conducted at the project-level. .

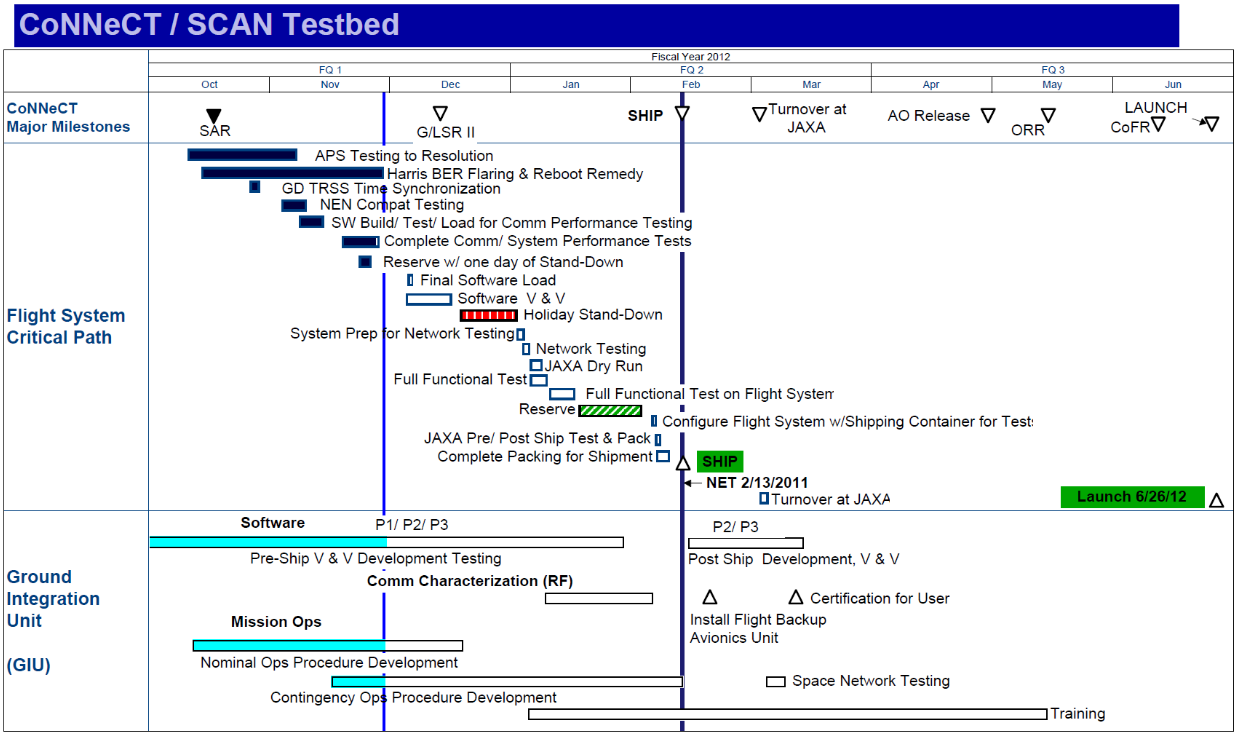


Figure 3-1—CoNNeCT FY12 Project Schedule

Figure 3-1 represents on overview of balance of the project schedule to shipment, turnover and launch. It includes the major milestone events such as the recently completed SAR and future events such as the Phase III Ground/Launch Safety Review, the Operational Readiness Review and ultimately longer-range milestones such as payload Checkout & Commissioning and Experiment Operations.

With the flight system assembly completed the major open work remaining as reflected in Figure 3-1 is continued refinement and testing of the software and the testing of the performance of the communication systems. Ultimately there will be a final functional test of the SCAN Testbed and the dry runs of the tests that will be performed in Japan prior to shipment. Those tests will serve as a “dress rehearsal” for the CoNNeCT team members that will travel to Japan and perform final tests prior to payload turnover.

The lower section of Figure 3-1 highlights the Ground Integration Unit (GIU) activities. The GIU is an extremely valuable system that is flight-like system and is used to validate software, communication testing, and mission operations. The GIU includes engineering models of the structure, avionics (including harnessing), and the three SDRs. The GIU also includes functionally equivalent RF subsystem and APS subsystems and flight software. This configuration enables sufficient pre-flight testing of SDR performance and sufficient fidelity for flight software verification (enabling software changes after shipment). Ultimately the Flight Spare Avionics Unit will be installed in the GIU. The GIU will also allow experimenters to develop flight procedures and perform dry runs of their experiments.

The Ground System and Mission Operations are developed in parallel with the Flight System. Key elements include Ground Software and Mission Operations procedures, leading to simulated mission scenarios to verify commands, operations scenarios, and mission sequence testing. Much of this work is accomplished on the GIU. Ground Software is integrated with Flight System testing as early as possible to buy down risk and make system testing command and telemetry interfaces more "user friendly." The initial flight activities conclude with on-orbit check-out and commissioning estimated to be approximately four months, depending on ISS and TDRSS operations and resources. Following the Check Out & Commissioning Phase in the first quarter of FY13, the Experiment Operations Phase of the project will commence.

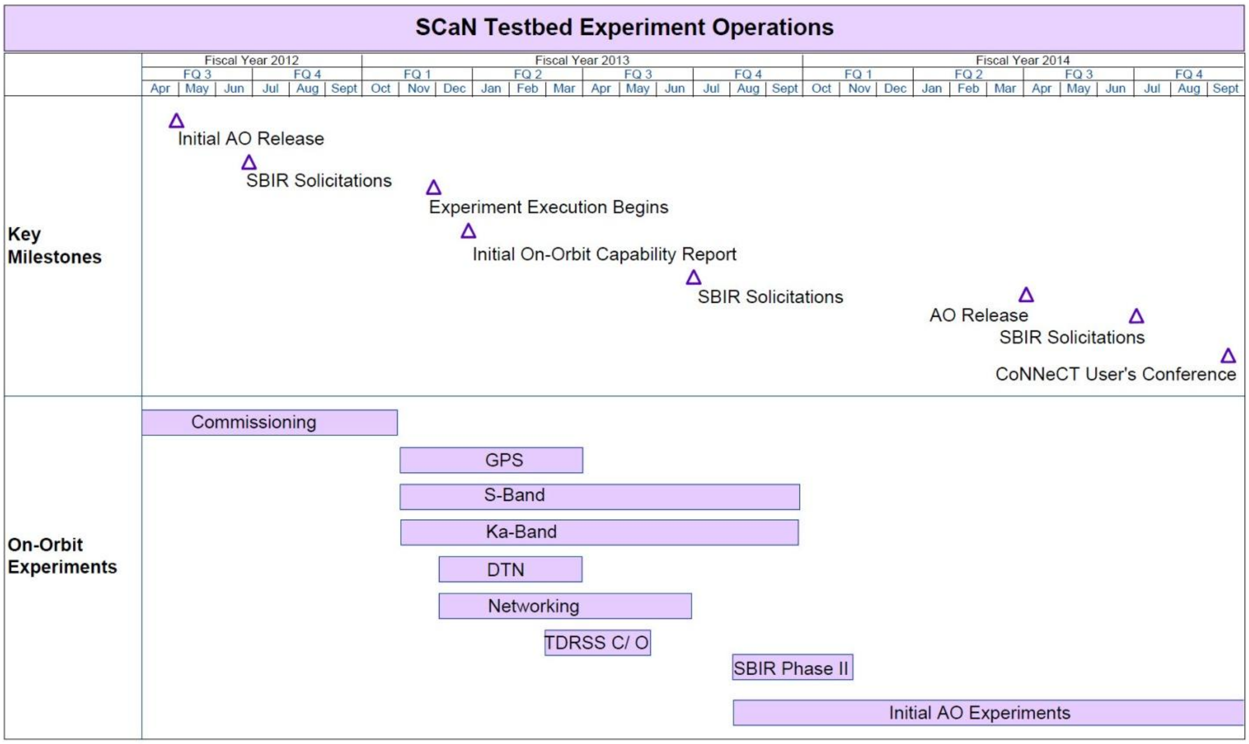


Figure 3-2—Experiment Operations Schedule

The top level schedule view of the initial Experiment Operations Phase through FY14 is depicted in Figure 3-2. Portions of the schedule address the solicitation and processing of experiments, including the NASA Announcement of Opportunity Process that will result in selected experiments performing on-orbit operations and subsequently reporting out in appropriate forums. Experimenters and Users will report results at appropriate conferences. In addition, CoNNeCT personnel will report out on the performance of the payload and the status of mission success.

The CoNNeCT Master Schedule is diligently managed and updated regularly. There is a weekly forum, the CoNNeCT Integrated Schedule meeting, to formally address schedule progress, threats and risks. The volume of the Master Schedule has been reduced significantly over time as the design, development, assembly, integration and test phases have been completed. The current schedule is now on the order of hundreds of line items whereas at one time the content was thousands of line items. Management schedule reserve has been diligently defined and tracked over the project. The current reserve prior to Flight System shipment to Japan is 13 working days.

3.4 Resource Baseline

The current baseline resources were developed from a bottoms-up development of the schedule and associated resources at each Center, with GRC being the largest element of cost. The estimates were then integrated and "scrubbed" to eliminate unnecessary work elements and to identify gaps in planning. The resource costs at each Center were more specifically calculated using their respective cost estimation tool.

All major procurements have been completed, Facilities costs at each of the partner Centers for development, sustaining engineering, integration and operations are included; no major infrastructure updates are required.

CoNNeCT's scope and budget does not include costs of carrier integration, launch services, or SN or NEN service costs, or other non-SCaN funded experiment development. The project is furnished with an ExPA to use throughout the on-orbit operations and is disposed of on-orbit with the CoNNeCT hardware. JAXA is supplying the launch services. The SCAN Testbed requires the use of NASA's TDRSS satellites, GPS satellites, and ground system communication services at White Sands Complex, Wallops Island, and the Huntsville Operations Control Center. The ISS program office provides interface testing for testing the CoNNeCT hardware with the Express Logistics Carrier (ELC) Simulator.

The baseline resources are summarized by Center, by WBS, and by FTE and Procurement & Travel in Tables 3.5, 3.6 and 3.7, respectively. Reserves are held by the SCaN Program Office.

Experiment agreement mechanisms, such as Space Act Agreements, may be negotiated for full reimbursement of NASA expenditures specific to that experiment's development, integration, and/or operation within the SCAN Testbed ISS Payload. In general, if the experiment is for the benefit of NASA, the Space Act Agreement will be non-reimbursable. If the experiment is no benefit to NASA, a fully reimbursable Space Act Agreement will be developed to recoup the project's incremental cost to integrate and operate the user. As shown in Table 3-4, the budget for Phase A – D for CoNNeCT without reserves is $104M, and Phase E/F is $77M. If annual PPBE in-guide resource marks are inconsistent with the resource profiles listed below, project execution will be reprioritized and some scope may go unfulfilled.

Table 3-4—CoNNeCT Budget by Center

Full Cost ($K)	FY08	FY09	FY10	FY11	FY12	Phase A-D Total	FY13	FY14	FY15	FY16	FY17	FY18	Phase E Total
GRC	10,802	18,770	26,070	19,804	9,934	**85,380**	8,586	8,745	8,911	9,078	9,053	9,032	**53,405**
GSFC	928	629	670	403	514	**3,144**	1,173	2,055	1,208	1,231	1,253	1,277	**8,197**
JPL	8,228		4,918	915	698	**14,759**	1,143	2,648	2,714	2,782	2,851	2,922	**15,060**
JSC	197	16	261	193	15	**682**	53	54	55	56	58	59	**334**
KSC			34	19		**53**							
MSFC			30	24		**54**							
Total	**20,155**	**19,415**	**31,983**	**21,359**	**11,161**	**104,073**	**10,955**	**13,501**	**12,888**	**13,147**	**13,215**	**13,290**	**76,996**

Table 3-5—CoNNeCT Budget by WBS

Full Cost - All Centers ($K)	FY08	FY09	FY10	FY11	FY12	Phase A-D Total	FY13	FY14	FY15	FY16	FY17	FY18	Phase E Total
1.0 Proj Mgmt	984	1,256	6,969	2,590	1,666	**13,465**	1,423	1,451	1,480	1,509	1,539	1,569	**8,971**
2.0 SE&I	1,096	1,953	4,220	10,070	2,203	**19,542**	2,461	2,513	2,567	2,622	2,678	2,736	**15,577**
3.0. S&MA	341	692	1,015	1,054	266	**3,368**	60	62	64	65	67	68	**386**
4.0 Experiments	14,272	8,406	3,057	4,084	3,047	**32,866**	5,465	7,037	7,173	7,312	7,256	7,205	**41,448**
5.0 Flight System	3,007	6,416	13,227			**22,650**							
6.0 Software			960	2,385	2,196	**5,541**							
7.0 Mission Ops	456	692	2,535	1,176	1,783	**6,642**	1,545	2,438	1,605	1,639	1,675	1,712	**10,614**
Full Cost ($K)	**20,156**	**19,415**	**31,983**	**21,359**	**11,161**	**104,074**	**10,955**	**13,501**	**12,888**	**13,147**	**13,215**	**13,290**	**76,996**

Table 3-6—CoNNeCT Workforce Plan

Resources	FY08	FY09	FY10	FY11	FY12	Phase A-D Total	FY13	FY14	FY15	FY16	FY17	FY18	Phase E Total
1.0 Proj Mgmt FTE				7.9	5.0		3.0	3.0	3.0	3.0	3.0	3.0	**18**
1.0 Proj Mgmt P&T ($K)	1,490	383	1,580	1,780	966	**6,199**	993	1,010	1,027	1,045	1,064	1,082	**6,221**
2.0 SE&I FTE				22.9	5.0		3.0	3.0	3.0	3.0	3.0	3.0	**18**
2.0 SE&I P&T ($K)	4,120	1,285	3,573	3,272	1,503	**13,753**	2,031	2,072	2,115	2,158	2,203	2,249	**12,827**
3.0 S&MA FTE				3.6	1.0		0.1	0.1	0.1	0.1	0.1	0.1	**0.6**
3.0 S&MA P&T ($K)	149	277	645	601	126	**1,799**	46	47	48	50	51	52	**295**
4.0 Expts FTE				6.8	9.5		12.3	12.3	12.3	12.3	12.3	12.3	**73.8**
4.0 Expts P&T ($K)	3,782	11,243	6,312	2,592	1,712	**25,639**	3,659	5,186	5,277	5,367	5,264	5,162	**29,915**
5.0 Flight System FTE													
5.0 Flt Sys P&T ($K)		1,641	9,129	3172		**13,942**							
6.0 SW FTE				11.1	3.5								
6.0 SW P&T ($K)			2,275	1,855	1,706	**5,836**							
7.0 Mission Ops FTE				4.1	2.8		1.3	2.8	1.3	1.3	1.3	1.3	**9.1**
7.0 Mis Ops P&T ($K)	6,796	601	888	769	1,383	**10,437**	1,355	2,008	1,413	1,444	1,474	1,506	**9,200**
Total FTE	**15.5**	**27.6**	**44.1**	**56.5**	**26.8**	**170.5**	**19.7**	**21.2**	**19.7**	**19.7**	**19.7**	**19.7**	**119.5**
Total P&T ($K)	**16,337**	**15,429**	**24,402**	**14,041**	**7,396**	**77,606**	**8,084**	**10,323**	**9,880**	**10,064**	**10,055**	**10,051**	**58,457**

4.0 PROJECT CONTROL PLANS

4.1 Technical, Schedule, and Cost Control Plan

Technical, schedule and cost performance control are accomplished through a number of mechanisms internal and external to the project.

First, the control of technical content is documented in the SEMP. As discussed earlier, the project's CCB formally controls any changes to project baselines through the processes defined in Section 2.4 and Appendix C (Board Charters). All proposed technical baseline changes to the project are reviewed and approved by the CCB before implementation. Any major changes to the technical baseline are reviewed first through ERB(s) as appropriate prior to coming to CCB. Each WBS lead is responsible for regular schedule status reports against planned work as documented in the master schedule in that WBS lead's area. In addition to internal project review of technical work, GRC Discipline Lead Engineers perform checks on work products at key points in the development to assure technical performance.

Project resources are allocated to each WBS element of the project. WBS Leads are responsible for management of their WBS element in terms of technical, schedule and cost performance, and report to and ultimately accountable to the PM. Resources are tied to lower level WBS element tasks defined by WBS development task plans. The WBS plans have associated milestones (which roll up to the Master Schedule) and deliverables. WBS resources are associated with WBS key milestones and performance and are evaluated on a regular basis. Control accounts are developed consistent with the project financial WBS structure and managed by the WBS Leads. Monthly reporting will provide the status of each control account's performance against the plan with a variance report for those whose costs vary from the plan by more than 10%.

Furthermore, every partner holds regular internal reviews at each of their facilities to monitor performance at their respective facility. The WBS cognizant leads and their Technical Representatives on all project sponsored contracts, cooperative agreements and other contractual instruments monitor regularly all such efforts for performance based on scheduled reviews defined by the respective contract/agreement. Line management at each of the partner Centers supporting CoNNeCT also regularly reviews technical performance through line organizational progress technical reviews.

Controls outside the project include reviews by GRC Space Flight Systems and the SCaN Program Office on a monthly basis, as well as quarterly reviews at the HEOMD Directorate Program Management Council. Variances on technical, budget, and schedule are reviewed and action plans are established as required for corrective action. The CoNNeCT budget is reviewed (and, if necessary altered) as part of the normal annual Program Planning, Budgeting and Execution (PPBE) process.

Changes may result from redirection in project scope requested by the program, schedule changes, or added technical content (after appropriate impact assessment and change control). The project works with the SCaN program office for any re-baseline changes to the CoNNeCT resources. Once baselined, the resources are controlled by the CCB with any changes requiring formal approval after CCB assessment on technical performance, schedule, and risk assessment. Project reserves are held by the SCaN Program Office at NASA HQ and are formally released via HQ Reserve Management Board (RMB) chaired by the DSP.

4.2 Project Descope

Project Descope Plans are developed by the PM as needed and the minimum success criteria help provide evaluation criteria for any descope. If minimum success cannot be achieved, the program considers a termination review of the project. Descope options are provided and reviewed as part of the major review process.

4.3 Mission Success

The following is the CoNNeCT Success Criteria originally baselined at SRR and updated August 2009 in GRC-CONN-RPT-0099.

The technology areas within the minimum and full success criteria can be divided between primary technology and secondary technology demonstration objectives. The primary technologies include fundamental SDR and STRS advancements and minimum capability for future missions. The secondary technology objectives include advanced operational aspects of the CoNNeCT technologies. Using SDRs represent a new way to accomplish communications (e.g. TDRSS transceiver/transponder) and navigation functions traditionally performed with single function radios and networking will demonstrate new functionality enabled by SDR-based systems. In addition, there are basic capabilities that the CoNNeCT System, as an adaptable orbiting testbed, needs to provide to experimenters to enable future software upgrades to the SDRs and avionics portion of the flight system.

A Minimally Successful Mission accomplishes the subset of Level 1 Requirements that provide significant contributions to SDR development and technology advancement and is defined as: achieving and demonstrating the primary technologies, the basic test bed capability, and any <u>2 of the 3</u> secondary technologies of the minimum success criteria. This requires the on-orbit system to be successfully developed, launched and operational as an external communications payload on the ISS.

A Fully Successful Mission accomplishes the subset of Level 1 Requirements that contributes to better understanding the application of SDRs to future missions thereby reducing the risk of infusing SDRs and other CoNNeCT technologies into NASA missions. Full Success goes beyond simple demonstration, but also entails understating those capabilities that best align with future mission needs. A Fully Successful Mission will achieve and demonstrate the primary technologies, the basic test bed capability criteria, and any 2 of the 3 secondary technologies of the full success criteria, demonstrating that the CoNNeCT System is capable of supporting future communications, navigation, and networking experiments. Demonstration of these technologies will enable greater science return on future missions and reduce future mission risk of adopting and utilizing these technologies.

Table 4-1 includes the minimum and full success criteria for CoNNeCT.

Table 4-1—CoNNeCT Success Criteria

		Title	Minimum Success	Full Success
Primary Technologies	1	Development and Space Qualification of STRS Compliant SDRs	Develop and space-qualify the CoNNeCT communication system consisting of two commercially supplied and one NASA developed STRS-compliant SDRs and associated waveforms built in compliance to the STRS Standard.	Operate at least two STRS-compliant SDRs in the space environment to demonstrate the STRS Architecture (v1.02) has achieved TRL-7.
Primary Technologies	2	SDR TRL Advancement	Demonstrate command, control, telemetry reception, and basic functionality from each sub-system (e.g. SDR, avionics, RF, gimbal) to and from the CoNNeCT Control Center. Verify nominal operation through received telemetry validating SDRs have achieved a minimum of TRL-6.	Operate at least two SDRs in the space environment and sustain an S-band or Ka-band communication link whose performance is adequately understood so that future behavior can be predicted with confidence and demonstrate that at least two SDRs have achieved TRL-7.
Primary Technologies	3	In-flight SDR Reconfiguration	Upload software and/or firmware from the CoNNeCT Control Center with new capabilities to at least two SDRs on-orbit and confirm its reception. Demonstrate that software and/or firmware uploaded to the SDRs is operational and validate the new operational characteristics.	Upload software and/or firmware from the CoNNeCT Control Center <u>or avionics</u>, to at least two SDRs on-orbit, <u>multiple times</u> and confirm the reception of the newly uploaded sw or fw. Demonstrate that the software and/or firmware uploaded to the SDRs is operational and validate the <u>change</u> in the operational characteristics.
Primary Technologies	4	S-band Communications	Demonstrate S-band RF link capability and functionality of an STRS-compliant SDR operating in the space environment. Have the SDR operate at S-band to and from TDRSS (Space Network) with at least 18 kbps forward link and 24 kbps return link.	Operate an STRS-compliant SDR in the space environment at S-band with TDRSS with at least 72 kbps forward link and 192 kbps return link and characterize performance with a bit error rate of 10^{-5} or better, or provide rationale for performance deviation.
Secondary Technologies	5	Ka-band Communications	Demonstrate a Ka-band RF link capability to and from TDRSS with an STRS-compliant SDR in the space environment. Acquire and track a Ka-band carrier and operate the SDR at Ka-band to and from TDRSS (Space Network) with least 3 Mbps forward link and 12.5 Mbps return link.	Operate an STRS-compliant SDR in the space environment at Ka-band with TDRSS with at least 6 Mbps forward link and 100 Mbps return link with a bit error rate of 10^{-5}, or better or provide rationale for performance deviation.
Secondary Technologies	6	GPS Navigation	Demonstrate L-band (i.e. GPS) RF link and SDR L-band sampling capability by recording raw data samples at L1, L2, or L5 on an STRS-compliant SDR in a space environment. Forward the recorded data to a ground-based operations center for analysis.	Demonstrate GPS receiver capability on an STRS-compliant, SDR in a space environment by simultaneously tracking L1, L2 or L5, generating an on-board navigation solution, and forwarding raw observables to a ground-based operations center.
Secondary Technologies	7	Networking/ Routing	Route data through the avionics received from at least one SDR RF link to the avionics or SDR destination using the network layer (e.g. IP or DTN) address of the received data stream.	Route data from an RF link of one SDR through the avionics to the RF link of a second SDR RF link based on a destination IP and DTN network layer address of the received data stream. Operate bi-directional S-band link and Ka-band links simultaneously, routing data from one link to another.
Experiment Test-bed Basic Capability	8	Ground-based SDR Subsystem for future Waveform Development	Provide a test report characterizing the performance differences between the flight and ground SDR subsystem to enable future waveform development and on-orbit verification and operation of the reconfigurable flight subsystems.[1]	Demonstrate that the ground-based SDR/avionics subsystem[1] is sufficient for verifying and operating flight software and/or firmware by successfully operating a new waveform software and/or firmware capability on at least one STRS-compliant SDR, uploaded from the CoNNeCT Control Center.
Experiment Test-bed Basic Capability	9	Avionics Software Reconfiguration	Upload experiment software to the avionics subsystem from the CoNNeCT Control Center after launch and validate its reception and operation.	
Experiment Test-bed Basic Capability	10	Data Storage/Data Retrieval	Store the data received from at least one STRS-compliant SDR RF link to the avionics memory. Retrieve data from the avionics memory and forward the data to the CoNNeCT Control Center for analysis.	Store the data received from at least one SDR RF link into memory of the avionics or an SDR and then retrieve the stored data from memory and send it over an SDR transmit RF link without dependence upon the ISS payload LAN data interface.

(1) The ground-based, subsystem consists of the SDRs and other available components (e.g. TWTA, switches, diplexers) that are functionally equivalent to the flight CoNNeCT communication system.

4.4 Safety and Mission Assurance (SMA) Plan

The GRC Safety and Mission Assurance lead develops the CoNNeCT Product Assurance Plan (PAP, GRC-CONN-PLAN-0006) to help assure safety and mission success. These requirements are addressed in ten main sections: Project Management, Assurance Reviews, Verification, System Safety, EEE and Mechanical Parts Control, Materials and Processes, Reliability, Availability and Maintainability, Quality Assurance, Continuous Risk Management (via Risk Management Plan, GRC-CONN-PLAN-0007), and Software Assurance (via Software Assurance Plan, GRC-CONN-PLAN-0085).

The Product Assurance Plan provides clear instruction to Project personnel on their responsibilities to implement the safety and mission assurance activities through the use of formal processes and methodologies. For CoNNeCT, this Plan defines the personnel responsibilities, documentation requirements, and general verification methodologies for accomplishing the product assurance requirements as specified in the GRC SARG (Spacecraft Assurance Requirements and Guidelines), GLM-QE-87002.

The Plan applies to both the CoNNeCT Flight System, and the CoNNeCT Ground System encompassing both the hardware and the software.

4.5 Mishap Preparedness and Contingency Plan

The project complies with the requirements of NPR 8621.1B, NASA Procedural Requirements for Mishap and Close Call Reporting, Investigating, and Recordkeeping, and the draft of GLPR 1720.1, GRC Center Mishap Preparedness and Contingency Plan. The objective of mishap and close call investigations is to improve safety by identifying what happened, where it happened, when it happened, why it happened, and what should be done to prevent recurrence and reduce the number and severity of mishaps.

NPR 8621.1B specifies how to respond to any mishap or close call from discovery through corrective action and closure. It contains requirements for classifying mishaps, establishing investigation authorities, and performing investigations. The NPR provides requirements to report, investigate, and document mishaps, close calls, and previously unidentified serious workplace hazards to prevent recurrence of similar accidents.

GLPR 1720.1 defines the roles and responsibilities associated with GRC's mishap preparedness and contingency process as well as the specific requirements and procedures to be followed by GRC organizations for reporting, responding to, and investigating mishaps. Per NPR 8621.1B, NASA's Mishap Classification Level and Type of Investigation to be conducted is listed in Table 4-2. GLPR 1720.1 also specifies roles and responsibilities for mishap preparedness and response. For example, the Center Director reports, by telephone or email, to the Administrator within 24 hours, and to the NASA Headquarters OSMA/SARD within one hour of learning of any NASA Type A, Type B or Type C mishap (only if it involves a lost-time injury or illness), or any non-occupational fatality of a NASA civil service employee or resident contractor that occurred onsite.

The project follows GLPR 1720.1 including the following key elements. The initial response by personnel in the area when an emergency mishap occurs is very critical and the person or persons observing the event should do one of the following as quickly as possible: 1) locate and use a NASA phone to call 911, 2) pull the nearest manual fire alarm box, or 3) call (216) 433-8888 from a cell phone. Second, GRC personnel (civil servants and contractors) shall report mishaps or close calls by going to https://nasa.ex3host.com/iris/quickincident/safety_default.asp and completing (at a minimum) all of the bold fields within 24 hours. Incident Reporting Information System (IRIS) will automatically notify Safety, Health, and Environmental Division (SHED) when this IRIS form is completed. Third, CoNNeCT S&MA, Chief Engineer, and Project Manager shall be notified. The project shall support mishap investigations and corrective actions that may result.

Table 4-2—Mishap Classification Level and Investigation Type

Classification Level & Investigation Type	Property Damage	Injury
Type A Mishap	Total direct cost of mission failure and property damage is $1,000,000 or more, *or* Crewed aircraft hull loss has occurred, *or* Occurrence of an unexpected aircraft departure from controlled flight (except high performance jet/test aircraft such as F-15, F-16, F/A-18, T-38, OV-10, and T-34, when engaged in flight test activities).	Occupational injury and/or illness that resulted in: A fatality, *or* A permanent total disability, *or* The hospitalization for inpatient care of 3 or more people within 30 workdays of the mishap.
Type B Mishap	Total direct cost of mission failure and property damage of at least $250,000 but less than $1,000,000.	Occupational injury and/or illness has resulted in permanent partial disability. *or* The hospitalization for inpatient care of 1-2 people within 30 workdays of the mishap.
Type C Mishap	Total direct cost of mission failure and property damage of at least $25,000 but less than $250,000.	Nonfatal occupational injury or illness that caused any workdays away from work, restricted duty, or transfer to another job beyond the workday or shift on which it occurred.
Type D Mishap	Total direct cost of mission failure and property damage of at least $1,000 but less than $25,000.	Any nonfatal OSHA recordable occupational injury and/or illness that does not meet the definition of a Type C mishap.
Close Call	An event in which there is no equipment/property damage or minor equipment/property damage (less than $1000), but which possesses a potential to cause a mishap.	An event in which there is no injury or only minor injury requiring first aid, but which possesses a potential to cause a mishap.

4.6 Risk Management Plan

Continuous Risk Management (CRM) is an organized, systematic decision-making process that identifies, analyzes, plans, tracks, controls, communicates, and documents risks in order to increase the likelihood of achieving project objectives. The CRM process is proactive in nature and structured to provide early insight through appropriate collection and use of data, implementation of proven analytical techniques, and through management review and verification. The integrated effect of various risk categories (e.g., safety, performance, cost, and schedule) is properly analyzed and evaluated. CRM activities support the entire life cycle from SRR through mission operations and disposal.

The Risk Management Plan (RMP), GRC-CONN-PLAN-0007, is directly based on the NASA Continuous Risk Management requirements in NPR 7120.5D, NASA Program and Projects Management Processes and Requirements, and NPR 8000.4, Risk Management Procedural Requirements. The CoNNeCT RMP outlines the RM process, roles, responsibilities, accountability, and authority, and how risks are communicated internally and externally throughout the project.

The Project baselined the Risk Management Plan in July 2009 including a new risk score card (Figure 4-1) based on the SCAN Program risk criteria, modified for the CoNNeCT Project. Given the fast track, schedule and cost critical nature of CoNNeCT, the cost and schedule consequences were set at relatively small increments (i.e. down to one week on schedule and $50K on cost). The project manages risks in an electronic risk database, Risk Management Implementation Tool (RMIT.)

LIKELIHOOD RATING		
Likelihood	Value	Range
Very High	5	76% - 99%
High	4	51% - 75%
Moderate	3	26% - 50%
Low	2	11% - 25%
Very Low	1	0% - 10%

CoNNeCT Scorecard

TIMEFRAME	
Near	0 to 1 Month
Mid	1 to 3 Months
Far	>3 Months
Time to Initiate Handling Strategy	

Risk Type	Sub Risk Type	1	2	3	4	5
Safety	Personnel	Minor injury not requiring first aid treatment.	Minor injury regarding first aid treatment.	Medical treatment for a minor injury, illness.	Permanent or major injury, illness or incapacitation.	Death
	Flight Systems	N/A	N/A	Minor damage to flight systems.	Major damage to flight systems	Loss of flight assets.
	Ground Facilities/ Equipment	Negligible damage to Non-Critical ground facilities or systems.	Minor damage to Non-Critical ground facilities or systems.	Moderate damage to critical ground facilities or systems. -Or- Loss of Non-critical	Major damage to critical ground facilities or systems	Loss of critical ground facilities or systems.
Technical	Requirements	No impact to meeting performance and/or other mission objectives.	L4 requirements and/or other mission objectives cannot be met.	L3 requirements and/or other mission objectives cannot be met.	L2 requirements and/or other mission objectives cannot be met.	L1 requirements and/or mission objectives cannot be met.
	Operations	Negligible impact to mission objectives/ operations	Minor impact to mission objectives/operations-workarounds available.	Moderate impact to mission objectives/operations.	Major impact to mission objectives/operations-workarounds not available.	Unable to achieve major mission objective/operations.
Cost		<$50K	$50K - $100K	$101K - $250K	$251K - $500K	>$500K
Schedule		1 week delay to major project milestone.	1-3 week delay to major project milestone. -Or- Minor impact to critical path.	3-4 week delay to major project milestone. -Or- 1 month delay to major program milestone. -Or- Moderate impact to critical path.	4-6 week delay to major project milestone. -Or- 1-3 month delay to major program milestone. -Or- Major impact to critical path.	>6 week delay to major project milestone. -Or- >3 month delay to major program milestone or cannot meet major program milestones.

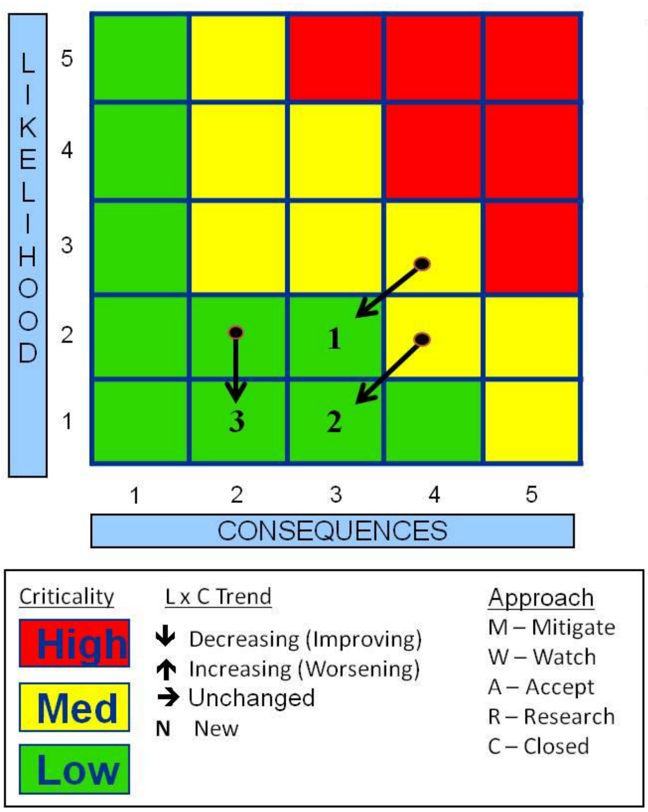
Figure 4-1—CoNNeCT Risk Scorecard

The current set of top risks are shown in Figure 4-2 and a sample Risk Chart is shown in Appendix D. The following discussion captures the trends of these risks.

Risk #1. Insufficient Processor Margin for High Rate is the top project risk. The avionics processor utilization is high when running the SDRs at high rates, which may impact the ability to run CPU intensive experiments, such as networking. Firmware upgrades on the Dynamic Engineering SpaceWire cards significantly improved functionality and processor margin and the SpaceWire and APS pointing and tracking code continues to be optimized. The processor can handle the high CPU intensive tasks, but not all of them simultaneously. Additional SW optimization is planned after the flight system is shipped to Japan.

Risk #2. Harris SDR Anomalies is another top project risk. The SDR has exhibited BER flaring and unexpected reboots, which may negatively impact mission operations. A new waveform was developed to correct the BER flaring issues and the Harris Operating Environment is being modified to resolve the unexpected reboots. Final verification is in process.

Risk #3. Avionics Reboot Anomalies is another top project risk. The avionics CPU can intermittently becomes saturated, resulting in the time out of the watchdog timer task. This causes the avionics to reboot itself, which may negatively impact mission operations if a solution is not identified before Check Out and Commissioning. The project is debugging the code to identify a root cause and implement corrective action. In addition, the ISS Payload Operations Director has been advised of the issue, in order to mitigate any additional negative impact to ISS operations as a result of the anomaly.



STATUS AS OF: 11/29/11

LxC Trend	Rank	Approach	Risk Title
↓	1	M	Insufficient Processor Margin for High Rates
↓	2	M	Harris SDR Anomalies
↓	3	M	Avionics Reboot Anomalies

Figure 4-2—CoNNeCT Top Risks

4.7 Software Assurance Plan

The Software Quality Assurance Plan provides the framework necessary to ensure a consistent approach to software quality assurance throughout the project life cycle. It defines the approach that will be used by the Software Quality (SQ) personnel to monitor and assess software development processes and products to provide objective insight into the maturity and quality of the software. The systematic monitoring of products, processes, and services will be evaluated to ensure they meet requirements and comply with National Aeronautics and Space Administration (NASA), Glenn Research Center (GRC), and project policies, standards, and procedures, as well as applicable Institute of Electrical and Electronic Engineers (IEEE) standards.

The GRC S&MA Software Assurance Engineer develops the CoNNeCT Software Assurance Plan (GRC-CONN-PLAN-0085). The Software Assurance Plan (SAP) complies with the NASA Software Safety Standard in NASA-STD-8719.13B, the NASA Software Assurance Standard in NASA-STD-8739.8, and the Institute of Electrical and Electronics Engineers (IEEE) Standard for Software Quality Assurance Plans in IEEE 730-2002.

4.8 Acquisition Plan

CoNNeCT utilizes a variety of procurement vehicles targeted to minimize procurement time (given the fast-track schedule of the project) while still providing an end item meeting requirements. The acquisition strategy includes a combination of in-house NASA civil servant (GRC with GSFC, JSC, and JPL support) and contractor (local support and prime) workforce, with their associated capabilities for flight development, as established by internal task agreements, contracts, cooperative agreements, and other procurement mechanisms. For example, the flight system Enclosure is a simple mechanical structure that is designed, fabricated, and tested utilizing in-house GRC engineering and services.

The project targets hardware with previous flight pedigree to minimize development/schedule issues. All three radios, GD, Harris, and JPL are based on their own heritage systems (e.g. JPL radio closely matches a Mars mission radio and GD is working on the 5^{th} generation of their radio). The GD and Harris radios are being provided via cooperative research agreements with GRC and the SDR Lead assigns a COTR to manage the development through turn-over and integration at GRC. Cooperative Agreements are not ideal for full government control of a given procurement. This control risk (that implies cost and schedule risk to the project) is mitigated by four factors. First, a successful flight of these radios provides a competitive advantage in the future; this is the reason for the Cooperative Agreement to enable future commercial SDRs government and non-government applications. Second, Senior Management at NASA Headquarters has obtained personal commitments by Senior Management at each of the three providers. Third, the technical teams assigned at each of the providers are high quality and are motivated to provide a quality product within reasonable cost and schedule. Finally, the SDR Lead communicates frequently to assess status and support development of revised plans when issues arise; the SDR Lead brings in the CoNNeCT PM for larger issues such as threats to delivery dates.

The Ka Band TWTA is being procured by GRC via an existing Lunar Reconnaissance Orbiter (LRO) contract and the RF/Antennas Lead assigns a COTR to manage the development through turn-over and integration at GRC. The antennas are procured by JPL via a competitive procurement process and oversight is provided by the RF/Antennas Lead. The non-custom payload avionics are procured via the NASA SEWP IV procurement vehicle and AITech was selected to provide a heritage card cage and cards, and the Avionics Lead manages. Two custom cards are designed and populated in-house at GRC under the

Avionics Lead. The antenna pointing system for the steerable antennas is procured via an open, competitive procurement from GRC and SpaceDev was selected. Their design matches the LRO system except for the mounting design and is managed by the APS/Gimbal Lead.

Partners and vendors conduct testing and verify their hardware prior to delivery to GRC. Integration of vendor hardware and system level integration, payload V&V, and environmental testing is conducted by GRC.

A list of project major procurements and long lead items is shown in Section 3.4. Project controls for technical, cost and schedule of these acquisitions are discussed in Section 4.1.

4.9 Technology Development Plan

The technology elements of CoNNeCT include the pre-flight development of the communication subsystem to TRL of 6. Pre-flight, this subsystem is verified to be compliant to a single SDR architecture standard, the Space Telecommunications Radio System (STRS). The key elements of this subsystem are the SDRs. The Experiment Communication Systems Lead is responsible for defining requirements and conducting assessments to verify TRL-6 has been achieved.

The SDR technology advancement of each SDR resides in the reconfigurable nature of the digital electronics, consisting of one or more reprogrammable field programmable gate arrays (FPGAs) and associated general purpose processors. The FPGAs allow the SDRs to operate at higher data rates and run more complex algorithms than with general-purpose processors alone. The FPGAs also consume less power than the processors, providing more capability at less power. The capability of the payload allows these processors and FPGA to be reprogrammed in flight. Along with the digital portion, the SDRs also have RF capability. The SDRs operate full duplex from user data through standard baseband interfaces to the RF interface of S-band, Ka-band, and receive L-band (GPS) frequencies.

The plan for the maturity of the technology of each radio is as follows. The Experiment Communication System Team conducted a series of trade studies and technology evaluations to determine the required capabilities for the fight system. One internal NASA provider, JPL, was approached to modify their Mars Reconnaissance Orbiter SDR to meet the advanced goals of CoNNeCT, as documented in the inter-Center Task Agreement between GRC and JPL including the delivery of breadboard, engineering model, flight unit, and software to GRC.

To enable the industry participants an opportunity to participate in the study of SDRs in space, a NASA Research Announcement was released and competed. Both General Dynamics and Harris were selected under the NRA to provide SDRs. Cooperative Agreements are used for both industry participants to facilitate the transfer of NASA funding to the company, the transfer of the SDR and software deliverables to NASA, and a mechanism for the industry to share the costs of the SDR development and participation in the experimental phase.

The Experiment Communication System Team worked closely with each SDR provider to further define the requirements and deliverables to design and mature each of the SDRs to TRL-6 (requirements defined and acceptable risk established before system PDR). This Team evaluates each SDR at development milestones (e.g. PDR, CDR) and prior to the delivery of breadboard, engineering, and flight hardware and software. Prior to acceptance of TRL-6, each SDR is tested in GRC ground testbeds, with the flight hardware tested on the GIU, then on the Flight System. This testing includes compliance with the STRS Standard. The combination of the Acceptance Data Package for each SDR and the SDR test verification at GRC completes the technology readiness process as documented at turnover of each SDR to the Flight System.

No other new technologies, less than a TRL of six (6), are identified for CoNNeCT.

4.10 Systems Engineering Management Plan (SEMP)

The CoNNeCT Systems Engineering and Integration Lead develops the Systems Engineering Management Plan (SEMP), document GRC-CONN-PLAN-0005, which describes the technical and integration approaches accepted for the design, development, test, and evaluation (DDT&E), deployment and operation of the CoNNeCT Project to organize work and to accomplish the project goals within cost and schedule requirements.

The SEMP further defines interfaces, roles, and responsibilities between the CoNNeCT Project and other organizations, and most important within the CoNNeCT Project Team including external partners at JAXA, GSFC, JSC, KSC, JPL, Harris, and GD. The SEMP also establishes the structure and processes to provide management with necessary information for making Systems Engineering (SE) decisions.

4.11 Software Management Plan

The CoNNeCT Software Lead develops the Software Management and Development Plan (SMDP), GRC-CONN-PLAN-0024, which establishes the approach for management and development of all software components of the CoNNeCT system. The CoNNeCT avionics software and waveform deliverables are produced in-house at GRC, while other waveforms are produced by partners at their locations. The SMDP describes the relationship between software development groups and how these groups work together to develop the complete software system. Software produced at GRC is managed according to this plan throughout development, while software produced by partners is managed at the interfaces through Interface Control Documents. GRC has responsibility for integration and test of the complete software system.

4.12 Review Plan

The project satisfies the intent of NPR 7120.8, NPR 7120.5 and NPR 7123.1 in its approach to reviews with some tailoring as noted below.

A Standing Review Board (SRB) was used through the System Acceptance Review (SAR) to assess the project's performance against the review criteria. Approximately half of the SRB membership was external to GRC, and half from within GRC. All review board members are independent from the CoNNeCT project. For all future reviews, a project level board will be used.

For each system level review, a specific plan is generated by the Lead Systems Engineer based on the SEMP, which establishes the project's deliverables and defines the expectations by which the review board should judge the project.

The CoNNeCT project conducts a system level Operational Readiness Review as a CoNNeCT ERB. The CoNNeCT SEMP describes each of these in more detail. Where appropriate, independent reviewer participation are included in the ERBs.

Experiment (User) reviews are conducted as depicted in Figure 1-6 and the SEMP describes the criteria for each of those reviews. A plan will be written by the LSE for each of the reviews and it will be approved by the PM and CE. The CoNNeCT Review Plan is detailed in the SEMP (GRC-CONN-PLAN-0005).

4.13 Mission Operations Plan

The detailed plan has been documented in the CoNNeCT Mission Operations Plan, GRC-CONN-PLAN-0133 and the Mission Operations Scenario Timelines, GRC-CONN-OPS-0429. The core concept is to operate the CoNNeCT System safely in accordance with ISS, Space Network, and Near Earth Network regulations and procedures. The CoNNeCT project prepares the tools and personnel for mission operations, conducts on-orbit Check Out and Commissioning, and executes the payload experiments operations which will begin after the completion of the Check Out and Commissioning Phase. The SCAN Testbed will perform operations for a minimum of two years on the ISS.

Routine operations consist of ISS, Space Network, and Near Earth Network scheduling coordination, procedure and timeline development, operations experiment validation testing on the GIU, and the actual operations on the Flight System. The Operations team coordinates with the experimenters as they develop their experiment plans and also coordinates development activities from an on-orbit experiment schedule, ground system development, and ISS, Space Network, and Near Earth Network perspective. The resulting experiments are planned and then fully tested and rehearsed on the GIU before being run on the Flight System..

Schedule coordination is a major element because of the multiple entities involved: ISS and the Payload Operations Integration Center (POIC), Space Network, and Near Earth Network. Each entity has an individual timeline that will be coordinated with the Project needs from the experiment, housekeeping, and maintenance perspective. Planning typically begins 4 to 6 weeks prior to the executed event, in order to allow for adequate coordination across the various supporting entities.

Off-nominal issues are handled according to their risk to the Flight System. Issues that could potentially damage the system are handled automatically on-board the Flight System. Lower priority issues are resolved from the CCC and may include testing and simulation with the GIU. Further detail is being developed in the Fault Detection Isolation and Recovery document, GRC-CONN-RPT-0227 and the Mission Operations Scenario Timelines, GRC-CONN-OPS-0429.

4.14 Environmental Management Plan

Activities conducted with support from the cognizant Environmental Management Office (EMO) include:

1. Identification of all required permits, waivers, documents, approvals, or concurrence required to show compliance with Federal, State, and local environmental regulations.

2. Documentation and schedule of events for complying with these regulations

3. The project schedule includes critical milestones associated with complying with the regulations.

The CoNNeCT project has identified no environmental impacts as called out in NPR 7120.5D.

4.15 Logistics Plan

The Integrated Logistics Support Plan (ILSP) (GRC-CONN-PLAN-0045) establishes the processes and specific plans for implementation of the ILS activities during development, testing, and operational phases while at GRC. The ISS Integration document, the Ground Processing Plan, covers the logistics planning for flight system shipment via airplane and boat to Japan and for final pre-launch processing within the Tanegashima Space Center.

The ILSP is a blueprint for the logistics infrastructure needed to support operations. Key elements of this plan include details of the following main logistics activities. GRC manufactured flight hardware, including spares is fabricated in GRC Bldgs 50 and 110 (avionics) and assembled at GRC Bldg. 333 clean rooms. Bonded storage facilities are maintained in Bldgs. 50 and 333. Outside vendor flight hardware is processed at the vendor's facilities and shipped to GRC Bldg. 333 clean room. Flight hardware is assembled and functionally tested in Bldg. 333. Flight hardware is shipped in custom shipping containers via truck within GRC for environmental testing. Finally, the Integrated Logistics Plan includes security details such as limited access to flight hardware, bonded storage, and training of personnel to immediately report any evidence of hardware tampering, etc. A Mishap Investigation Board is invoked if any significant flight hardware damage or theft occurs.

4.16 Data Management Plan

The Data Management Plan will provide guidance on how CoNNeCT will manage all the data from the Flight System, GIU, Space Network, Near Earth Network, ISS, and experimenters. It will specify the types of data, storage location, storage duration, data naming conventions, and various other items that will be necessary for both the Project and experimenters to successfully complete experiments.

4.17 Information and Configuration Management Plan

The configuration management process for CoNNeCT Configuration end items, enabling products, and other work products placed under configuration control are identified in the CoNNeCT Configuration Management Plan (GRC-CONN-PLAN-0002). This activity supports the required development, maintenance and control of the engineering documentation and data that defines the CoNNeCT performance and functional characteristics, and associated design, manufacturing, testing, checkout, and operations requirements; and verification that the flight hardware and software are in compliance thereto. CM is inherent to and required by good engineering and program management practices. This CM plan addresses the five functions of CM: (1) configuration management planning and management, (2) configuration identification, (3) configuration control, (4) configuration status accounting, and (5) configuration verification.

CoNNeCT CM is responsible for maintenance of an electronic database containing all project documentation from SRR through flight. The database has controlled access for the project team and is hosted by an eRoom server and web interface. The project CM has the responsibility to ensure identification and control of project records. At the end of the project, the PM has responsibility for final disposition of project records in accordance with NPD 1440.6, *NASA Records Management,* and NPR 1441.1, *Records Retention Schedules.*

The science and technology gained from CoNNeCT is primarily captured in technical papers and journal articles and is the responsibility of the PI and his team. This knowledge sharing is in compliance with NPD 2200.1, *Management of NASA Scientific and Technical Information*, and NPR 2200.2B, *Requirements for Documentation, Approval, and Dissemination of NASA Scientific and Technical Information*. The PI Team also works directly with the relevant stakeholders to more specifically infuse technology information into flight system planning through interaction with communications and navigation leads (e.g. Lunar Relay Network technologies are worked with the Constellation Program communications leadership).

CoNNeCT captures and applies lessons learned in accordance with NPR 7120.6 *Lessons Learned Process*, in several ways. The project engaged the GRC's Lessons Learned POC to both obtain and share lessons learned throughout the progress of CoNNeCT and to infuse lessons learned from other relevant projects/activities at GRC and across the Agency (e.g. LRO TWTA). Additionally, regular 4D assessments are utilized to capture team members' suggestions for improving project processes. Members of the project have actively engaged projects similar to CoNNeCT in terms of scope and schedule (e.g. LCROSS) for lessons learned infusion. Finally, the CoNNeCT Risk Facilitator transfers risk lessons to the lessons learned database.

4.18 Security Plan

The CoNNeCT Project Security Plan covers two distinct areas: Information Technology (IT) Security and physical security, covered by an IT Security Plan and Integrated Logistics Support Plan, respectively. The Integrated Logistics Support Plan is described in Section 4.9.2.

IT Security is the responsibility of the CoNNeCT PM and each member of the team to ensure safeguards for the integrity, availability, and confidentiality of Information Technology (IT) (e.g., hardware, software, data, information, applications, and systems) is in accordance with NPR 2810.1, Security of Information Technology. Additional requirements are as follows:

All CoNNeCT civil service and on-site contractors shall:

- Complete IT security awareness and training as required and provided by their respective Centers through SATERN.
- Report any suspected or actual IT security incidents to the CoNNeCT PM or designee and their respective Center IT Security Manager.
- Transfer commodities (e.g. hardware, software, information, etc) in compliance with NPR 2810.1 and NPR 2190.1A; NASA Export Control Program.
- Ensure that all CoNNeCT Project task information/data that is presented at all conferences goes through the appropriate review processes at the CoNNeCT task personnel's respective center, and that a copy of the approved paper/presentation is uploaded to the CoNNeCT eRoom for dissemination throughout the CoNNeCT Project team.

NPR 2810.1 applies to all NASA employees and NASA contractors (as provided by the terms and conditions of their respective contract), where appropriate in achieving Agency missions, programs, projects, and institutional requirements. Facilities, resources, and personnel under a contract or grant from NASA at a college, university, or research establishment are included in the applicability of NPR 2810.1 to the extent prescribed by the contract, grant, cooperative agreement, or other agreement.

4.19 Export Control Plan

Export Control for the CoNNeCT Project is administered by the Deputy Project Manager with support from the NASA Glenn Research Center Export Control Representative and implemented by the CoNNeCT Project Staff. The CoNNeCT External Interfaces Lead is the singular point of contact with JAXA for transfer of all CoNNeCT information and supports the Deputy Project Manager in the administration of Export Control (i.e. obtaining Export Control License, determination of Export Control Information that is restricted and therefore requires special handling).

The CoNNeCT Project contains hardware that is specifically designed or can be modified as a subsystem for a Spacecraft System or Associated Equipment articles, specifically, the Software Defined Radios (SDRs). The SDRs are designated U.S. Munitions List (USML) XV (e), as defined in the International Traffic in Arms Regulations (ITAR), 22 CFR 120-130, and are export controlled.

Technical data (e.g. detailed design, development, manufacturing, or production data) and Software directly related to the Radios are classified as USML XV(f), as defined in the International Traffic in Arms Regulations (ITAR), 22 CFR 120-130, and is export controlled.

The three USML XV(e) designated Radios are embedded within the SCAN Testbed and are launched to the ISS via a Japan Aerospace Exploration Agency (JAXA) launch vehicle. The SCAN Testbed is therefore designated USML XV(e) and requires an Export Control License with all supporting paperwork (i.e. DS 2032) to be initiated January 2010 and completed with approvals no later than the ship date (currently targeted for July 2011).

There is no transfer of Detailed Technical Data/Software of the SDRs to JAXA. The transfer of Detailed Technical Data for the SCAN Testbed to JAXA employs the *Export Control Guidelines for ATV and HTV Development, Integration and Operations* (Rev 5-12-04) exemption. Export of SCAN Testbed Detailed Technical Data is through the GRC Export Control Information System (ECIS) by the CoNNeCT External Interfaces Lead.

The SCAN Testbed is processed in Japan by US citizens. There are no provisions to expose the SDRs in Japan (ground processing is limited to post-shipping health checks of the SCAN Testbed). The SCAN Testbed is turned-over to JAXA for integration with the launch vehicle. The hardware employs anti-tamper or tamper-evident indicators which are checked within days of the launch (launch-pad late access). Once on-orbit, another visualization of the SCAN Testbed is conducted by robotics.

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5.0 WAIVER LOG

Requests for waivers to NPR 7120.5D requirements are documented and submitted for approval using the NPR 7120.5D Waiver Form. These requests are documented and attached to a single waiver to assure proper routing and control. The following are the known waivers from NPR 7120.5D requirements:

- English, not metric system used
- Level I HQ SPF requirement: will not eliminate all SPF's, mitigate through design and development as much as possible (process waiver to officially communicate and obtain approval for exceptions)

In addition to these waivers, the Project has identified documents that are not applicable, or, have such small content that they have been included in this Project Plan or another plan as follows:

- Planetary Protection Plan – Not Applicable
- Business Case Analysis for Infrastructure – Not Applicable
- Range Safety Risk Assessment Plan – Not Applicable
- Missile System Pre-launch Safety Package – Not applicable; follow HTV safety requirements.
- Orbital Debris Assessment - Cover potential disposal debris in the Disposal Plan.
- Environmental Management Plan - Incorporate into Project Plan
- Export Control Plan – Incorporate into Project Plan
- Technology Readiness Assessment - Incorporate into Project Plan
- Mishap Preparedness and Contingency Plan – Incorporate into Project Plan

APPENDIX A ACRONYMS AND ABBREVIATIONS

AA	Associate Administrator
APM	Associate Project Manager
ASIC	Application Specific Integrated Circuit
APS	Antenna Pointing System
ATP	Authority to Proceed
CCB	CoNNeCT Control Board
CDR	Critical Design Review
CCC	CoNNeCT Control Center
CE	Chief Engineer
CIL	Critical Items List
CoNNeCT	Communications Navigation and Networking reConfigurable Testbed
C3I	Command, Control, Communications, and Information
CMC	Center Management Council
CO	Contracting Officer
COTR	Contracting Officer's Technical Representative
CPARS	Corrective and Preventive Action Reporting System
CA	Cooperative Agreement
CRM	Continuous Risk Management
CTIM	CoNNeCT Technical Integration Meetings
CxP	Constellation Program
DA	Decision Authority
DAA	Deputy Associate Administrator
DLE	Discipline Lead Engineer
DoD	Department of Defense
DPM	Deputy Project Manager
DPMC	Directorate Program Management Council
DSP	Director of Systems Planning
DTN	Disruptive Tolerant Network (or Delay Tolerant Networking)
ED	Engineering Directorate
EDMP	Experiment Data Management Plan
EDS	Experiment Development System
ELC	Express Logistics Carrier
EMB	Engineering Management Board
EM	Engineering Model
EMI/EMC	Electromagnetic Interference/Electromagnetic Compatibility
EMC	Engineering Management Council
EPL	Electric Propulsion Lab (GRC Bldg. 301)
EPMP	Multi Purpose Exposed Pallet
ERB	Engineering Review Board
ESMD	Exploration Systems Mission Directorate
EVA	Extra Vehicular Activity
EVMS	Earned Value Management System
EVR	Extra Vehicular Robotics
EXPRESS	Expedite the Processing of Experiments to Space Station
ExPA	EXPRESS Payload Adapter
FM	Flight Model
FPGA	Field Programmable Gate Arrays
FRAM	Flight Releasable Attachment Mechanism
FMEA	Failure Modes Effect Analysis
FRR	Flight Readiness Review
FTA	Failure Tree Analysis
GD	General Dynamics
GIU	Ground Integration Unit
GN	Ground Network
GNUG	Ground Network User's Guide
GPM	General Purpose Module

GPP	General Purpose Processor
GPS	Global Positioning System
GRC	Glenn Research Center
GSFC	Goddard Space Flight Center
HAL	Hardware Abstraction Layer
Harris	Harris Corporation
HDR	High Data Rate
HEOMD	Human Exploration and Operations Mission Directorate
HID	Hardware Interface Description
HQ	Headquarters (NASA)
HTV	H-IIB Transfer Vehicle
IEEE	Institute of Electrical and Electronic Engineers
IF	Intermediate Frequency
ILSP	Integrated Logistics Support Plan
IRS	Incident Reporting Information System
ISS	International Space Station
IT	Information Technology
ITAR	International Traffic in Arms Regulations
JAXA	Japanese Aerospace eXploration Agency
JPL	Jet Propulsion Lab
JSC	Johnson Space Center
JTRS	Joint Tactical Radio System
KDP	Key Decision Points
KSA or KaSA	Ka-band Single Access on TDRSS 8-10
KSC	Kennedy Space Center
LCROSS	Lunar Crater Observation and Sensing Satellite
LDR	Low Data Rate
LE	Lead Engineer
LLIL	Limited Life Items List
LRO	Lunar Reconnaissance Orbiter
LSE	Lead Systems Engineer
LSIE	Lead Software Integration Engineer
MA	Multiple Access
Mbps	Mega bits per second
MCR	Mission Concept Review
MDR	Medium Data Rate
MILA	Merritt Island Launch Area
MOA	Memorandum of Agreement
MRB	Material Review Board
NEN	Near Earth Network (formerly called Ground Network)
NRA	NASA Research Announcement
OE	Operating Environment
QoS	Quality of Service
OPSCON	Operations Concept
OS	Operating System
OTA	Over-the-Air
PAP	Product Assurance Plan
PCA	Program Commitment Agreement
PDR	Preliminary Design Review
PE	Program Executive
PHL	Preliminary Hazards List
PI	Principal Investigator
PIM	Payload Integration Manager
PM	Project Manager
PMC	Program Management Council
PN	Pseudo random Noise
POC	Point of Contact
POIC	Payload Operations Integration Center

PP	Project Plan
PPBE	Planning, Programming, Budgeting, & Execution
POSIX	Portable Operating System Interface
PRACA	Problem Reporting and Corrective Action
PRB	Project Review Board
QPSK	Quadrature Phase Shift Keying
RAM	Random Access Memory
RF	Radio Frequency
RFA	Request for Action
RFM	Radio Frequency Module
RID	Review Item Discrepancy
RMB	Reserve Management Board (HQ)
RMP	Risk Management Plan
RRB	Risk Review Board
RT	Reconfigurable Transceiver
RTD	Research and Technology Directorate
RTOS	Real-Time Operating System
SA	Single Access
SAP	Software Assurance Plan
SAR	System Acceptance Review
SARG	Space Assurance Requirements and Guidelines
SCaN	Space Communications and Navigation
SDR	Software Defined Radio
SDS	Software Development System
SEMP	Systems Engineering Management Plan
SFSD	Space Flight Systems Directorate
SMA or SM&A	Safety and Mission Assurance
SMB	S&MA Management Board
SMAD	Safety and Mission Assurance Directorate
SMDP	Software Management and Development Plan
SME	Subject Matter Expert
SN	Space Network
SNUG	Space Network User's Guide
SPF or SPFL	Single Point Failure or Single Point Failure List
SPM	Signal Processing Module
SQ	Software Quality
SRB	Standing Review Board
SRR	System Requirements Review
STRS	Space Telecommunications Radio System
TA	Task Agreements
TASS	TDRSS Augmentation Service for Satellites
TCP	Transmission Control Protocol
TDRS	Tracking Data Relay Satellite
TDRSS	Tracking Data Relay Satellite System
ToR	Terms of Reference
TRL	Technology Readiness Level
TRR	Test Readiness Review
TT&C	Telemetry, Tracking And Control
TWTA	Traveling Wave Tube Amplifier
USML	U.S. Munitions List
VLDR	Very Low Data Rate
V&V	Validation and Verification
WBS	Work Breakdown Structure
WCA	Worst Case Analysis
WSC	White Sands Complex

APPENDIX B DEFINITIONS

Activity: (1) Any of the project components or research functions that are executed to deliver a product or service or provide support or insight to mature technologies. (2) A set of tasks that describe the technical effort to accomplish a process and help generate expected outcomes.

Advanced Technology Development: ATD is one of four interrelated NASA product lines. ATD programs and projects are investments that produce entirely new capabilities or that help overcome technical limitations of existing systems. ATD is seen as a bridge between BAR and actual application in NASA, such as FS&GS projects or elsewhere. ATD projects typically fall within a Technology Readiness Level (TRL) range of 4 to 6.

Architecture and Design: A description of the mission elements, their interfaces, their logical and physical layout, and the analysis of the design to determine expected performance and margins. Includes System Design Synthesis, System Design Analysis, and System Design Validation products.

Baseline: An agreed-to set of requirements, designs, or documents that will have changes controlled through a formal approval and monitoring process.

Configuration Management: A systematic process for establishing and maintaining control and evaluation of all changes to baseline documentation, products (Configuration Items), and subsequent changes to that documentation which defines the original scope of effort. The systematic control, identification, status accounting, and verification of all Configuration Items throughout their life cycle.

Contractor: Per NPR 7123.1, a “contractor” is an individual, partnership, company, corporation, association, or other service having a contract with the Agency for the design, development, manufacture, maintenance, modification, operation, or supply of items or services under the terms of a contract to a program or project within the scope of this NPR. Research grantees, research contractors, and research subcontractors are excluded from this definition.

Customer: The organization or individual that has requested a product and will receive the product to be delivered. The customer may be an end user of the product, the acquiring agent for the end user, or the requestor of the work products from a technical effort. Each product within the system hierarchy has a customer. A subset of “stakeholders.” (Refer to Stakeholder.)

Decision Authority: The Agency’s responsible individual who authorizes the transition at a KDP to the next life-cycle phase for a program/project.

Designated Governing Authority: The management entity above the program, project, or activity level with technical oversight responsibility.

Entry Criteria: Minimum accomplishments each project needs to fulfill to enter into the next life-cycle phase or level of technical maturity.

Exit Criteria: Specific accomplishments that should be satisfactorily demonstrated before a project can progress to the next product-line life-cycle phase.

Expectation: Statements of needs, desires, capabilities, and wants that are not expressed as a requirement (not expressed as a “shall” statement) is to be referred to as an “expectation.” Once the set of expectations from applicable stakeholders is collected, analyzed, and converted into a “shall” statement, the “expectation” becomes a “requirement.” Expectations can be stated in either qualitative (nonmeasurable) or quantitative (measurable) terms. Requirements are always stated in quantitative terms. Expectations can be stated in terms of functions, behaviors, or constraints with respect to the product being engineered or the process used to engineer the product.

Flight Systems and Ground Support: FS&GS is one of four interrelated NASA product lines. FS&GS projects result in the most complex and visible of NASA investments. To manage these systems, the Formulation and Implementation phases for FS&GS projects follow the NASA project life-cycle model consisting of phases A (Concept Development) through F (Closeout). Primary drivers for FS&GS projects are safety and mission success.

Formulation Phase: The first part of the NASA management life cycle defined in NPR 7120.5 where system requirements are baselined, feasible concepts are determined, a system definition is baselined for the selected concept(s), and preparation is made for progressing to the Implementation phase.

Implementation Phase: The part of the NASA management life cycle defined in NPR 7120.5 where the detailed design of system products is completed and the products to be deployed are fabricated, assembled, integrated, and tested; and the products are deployed to their customers or users for their assigned use or mission.

Interface Control Document (ICD): A specification of the mechanical, thermal, electrical, power, command, data, and other interfaces that system elements must meet.

Key Decision Point: The event at which the Decision Authority determines the readiness of a program/project to progress to the next phase of the life cycle (or to the next KDP).

Level 1 Requirement: A Project's fundamental and basic set of requirements levied by the Program or Headquarters on the project.

Logical Decomposition: The decomposition of the defined technical requirements by functions, time, and behaviors to determine the appropriate set of logical models and related derived technical requirements. Models may include functional flow block diagrams, timelines, data control flow, states and modes, behavior diagrams, operator tasks, and functional failure modes.

Measure of Effectiveness: A measure by which a stakeholder's expectations will be judged in assessing satisfaction with products or systems produced and delivered in accordance with the associated technical effort. The MOE is deemed to be critical to not only the acceptability of the product by the stakeholder but also critical to operational/mission usage. An MOE is typically qualitative in nature or not able to be used directly as a "design-to" requirement.

Measure of Performance: A quantitative measure that, when met by the design solution, will help ensure that an MOE for a product or system will be satisfied. These MOPs are given special attention during design to ensure that the MOEs to which they are associated are met. There are generally two or more measures of performance for each MOE.

Other Interested Parties: A subset of "stakeholders," other interested parties are groups or individuals that are not customers of a planned technical effort but may be affected by the resulting product, the manner in which the product is realized or used, or have a responsibility for providing life-cycle support services. A subset of "stakeholders." (Refer to Stakeholder.)

Operations Concept: A concept that defines how the mission will be verified, launched, commissioned, operated, and disposed of. Defines how the design is used to meet the requirements.

Peer Review: Independent evaluation by internal or external subject matter experts who do not have a vested interest in the work product under review. Peer reviews can be planned focused reviews conducted on selected work products by the producer's peers to identify defects and issues prior to that work product moving into a milestone review or approval cycle.

Product: A part of a system consisting of end products that perform operational functions and enabling products that perform life-cycle services related to the end product or a result of the technical efforts in the form of a work product (e.g., plan, baseline, or test result).

Product-Based WBS Model: Refer to WBS model.

Product Realization: The act of making, buying, or reusing a product, or the assembly and integration of lower level realized products into a new product, as well as the verification and validation that the product satisfies its appropriate set of requirements and the transition of the product to its customer.

Program: A strategic investment by a mission directorate (or mission support office) that has defined goals, objectives, architecture, funding level, and a management structure that supports one or more projects.

Project: (1) A specific investment having defined goals, objectives, requirements, life-cycle cost, a beginning, and an end. A project yields new or revised products or services that directly address NASA's strategic needs. They may be performed wholly in-house; by Government, industry, academia partnerships; or through contracts with private industry. (2) A unit of work performed in programs, projects, and activities.

Realized Product: The desired output from the application of the four Product Realization Processes. The form of this product is dependent on the phase of the product-line life cycle and the phase exit criteria.

Relevant Stakeholder: Refer to Stakeholder.

Requirement: The agreed upon need, desire, want, capability, capacity, or demand for personnel, equipment, facilities, or other resources or services by specified quantities for specific periods of time or at a specified time expressed as a "shall" statement. Acceptable form for a requirement statement is individually clear, correct, feasible to obtain, unambiguous in meaning, and can be validated at the level of the system structure at which stated.

Risk: The combination of the probability that a program or project will experience an undesired event (some examples include a cost overrun, schedule slippage, safety mishap, health problem, malicious activities, environmental impact, failure to achieve a needed scientific or technological breakthrough or mission success criteria) and the consequences, impact, or severity of the undesired event, were it to occur. Both the probability and consequences may have associated uncertainties. (Reference 7120.5.)

Software: As defined in NPD 2820.1, NASA Software Policy.

Specification: A document that prescribes, in a complete, precise, verifiable manner, the requirements, design, behavior, or characteristics of a system or system component.

Stakeholder: A group or individual who is affected by or is in some way accountable for the outcome of an undertaking. The term “relevant stakeholder” is a subset of the term “stakeholder” and describes people or roles that are designated in a plan for stakeholder involvement. Since “stakeholder” may describe a very large number of people, a lot of time and effort would be consumed by attempting to deal with all of them. For this reason, “relevant stakeholder” is used in most practice statements to describe the people identified to contribute to a specific task. There are two main classes of stakeholders. Refer to “customers” and “other interested parties.”

Success Criteria: Specific accomplishments that must be satisfactorily demonstrated to meet the objectives of a technical review so that a technical effort can progress further in the life cycle. Success criteria are documented in the corresponding technical review plan.

Surveillance-Type Projects: A project where prime or external contractors do the majority of the development effort that requires NASA oversight.

System: (a) The combination of elements that function together to produce the capability to meet a need. The elements include all hardware, software, equipment, facilities, personnel, processes, and procedures needed for this purpose. (Refer to NPR 7120.5.) (b) The end product (which performs operational functions) and enabling products (which provide life-cycle support services to the operational end products) that make up a system. (Refer to WBS definition.)

Systems Approach: The application of a systematic, disciplined engineering approach that is quantifiable, recursive, iterative, and repeatable for the development, operation, and maintenance of systems integrated into a whole throughout the life cycle of a project or program.

Systems Engineering Engine: The SE model provides the 17 technical processes and their relationship with each other. The model is called an “SE engine” in that the appropriate sets of processes are applied to the products being engineered to drive the technical effort.

Systems Engineering Life-Cycle: Concept Studies (Phase A), Preliminary Analysis and Definition (Phase B), Design (Phase C), Development (Phase D), Mission Operations (Phase E) and Disposal (Phase F) are the systems engineering life-cycle phases. Development includes Acquisition, Fabrication, and Integration; Verification and Preparation for Deployment; and Deployment and Operations Verification.

Systems Engineering Management Plan (SEMP): The SEMP identifies the roles and responsibility interfaces of the technical effort and how those interfaces will be managed. The SEMP is the vehicle that documents and communicates the technical approach, including the application of the common technical processes; resources to be used; and key technical tasks, activities, and events along with their metrics and success criteria.

System Safety Engineering: The application of engineering and management principles, criteria, and techniques to achieve acceptable mishap risk, within the constraints of operational effectiveness and suitability, time, and cost, throughout all phases of the system life cycle.

System Structure: A system structure is made up of a layered structure of product-based WBS models. (Refer to WBS definition.)

Technical Performance Measures: The set of critical or key performance parameters that are monitored by comparing the current actual achievement of the parameters with that anticipated at the current time and on future dates. Used to confirm progress and identify deficiencies that might jeopardize meeting a system requirement. Assessed parameter values that fall outside an expected range around the anticipated values indicate a need for evaluation and corrective action. Technical performance measures are typically selected from the defined set of Measures of Performance (MOPs).

Technology Readiness Level: Provides a scale against which to measure the maturity of a technology. TRLs range from 1, Basic Technology Research, to 9, Systems Test, Launch, and Operations. Typically, a TRL of 6 (i.e., technology demonstrated in a relevant environment) is required for a technology to be integrated into an SE process.

Technical Risk: Risk associated with the achievement of a technical goal, criterion, or objective. It applies to undesired consequences related to technical performance, human safety, mission assets, or environment.

Validation (of a product): Proof that the product accomplishes the intended purpose. Validation may be determined by a combination of test, analysis, and demonstration.

Validated Requirements: A set of requirements that are well-formed (clear and un-ambiguous), complete (agrees with customer and stakeholder needs and expectations), consistent (conflict free), and individually verifiable and traceable to a higher-level requirement or goal.

Verification (of a product): Proof of compliance with specifications. Verification may be determined by test, analysis, demonstration, and inspection.

Waiver: A documented agreement intentionally releasing a program or project from meeting a requirement. (Some Centers use deviations prior to Implementation and waivers during Implementation).

WBS Model: Model that describes a system that consists of end products and their subsystems (perform the operational functions of the system), the supporting or enabling products (for development; fabrication, assembly, integration, and test; operations; sustainment; and end-of-life product disposal or recycling), and any other work products (plans, baselines) required for the development of the system. Refer to the example product-based WBS for an aircraft system and one of its subsystems (navigation subsystem) below:

APPENDIX C PROJECT BOARD CHARTERS

C.1 CoNNeCT Control Board (CCB) Charter

C.1.1 Purpose

This document establishes the CoNNeCT Project Control Board (CCB) and sets forth its responsibilities, membership, and relationship with other NASA Centers.

The purpose of the CCB is to be a decision-making body that approves and controls the baseline of the CoNNeCT Project.

C.1.2 Applicability/Scope

This Charter is applicable to NASA GRC CoNNeCT Project, within the GRC Space Flight Systems Directorate.

C.1.3 Functions

The CCB is chartered by the CoNNeCT Project Office. Each member of the CCB is expected to represent the best interest of the Agency in the exercise of its functions. The functions of the CCB are as follows:

a. Approve and control changes to the baseline.

b. Evaluate cost, schedule, and programmatic impacts.

c. Ratify intra-GRC organizational agreements.

d. Coordinate and resolve issues and action items.

e. Review recommendations from the CoNNeCT Engineering Review Board (ERB), which serves as a pre-board for the CCB.

f. After SAR, perform the function of the RRB.

C.1.4 Membership

The members of the CCB are as follows:

a. CoNNeCT Project Manager, Chair

b. CoNNeCT Chief Engineer

c. Safety and Mission Assurance, Principle Investigator, and other WBS Leads, as necessary

d. CCB Secretariat – non-voting

C.1.5 Leadership and Controls

a. Formal decision-making body for project. PM is final authority.

b. Chaired by PM with CE as a voting member. S&MA, WBS Leads and PI nominally attend all meetings, however, are not required for all topics.. CCB Secretariat is a nonvoting member. Others added as appropriate.

c. Once baselined, formally control major changes from baseline per CM plan.

d. CCB secretariat will facilitate CM controls and adherence to CM plan.

e. PM or designee will coordinate with project's financial analyst to facilitate resource controls and management of reserves.

C.1.6 Meetings

a. The CCB convenes on an as needed basis.

b. The CCB is chaired by the CoNNeCT Project Manager. The CoNNeCT Deputy Project Manager is alternate chair..

c. The CCB Secretariat sends out the agenda and presentation material to the Board Members prior to the meeting.

d. The CCB Secretariat tracks action items and record all of the dispositions from the CCB.

e. The CCB Secretariat sends out the meeting minutes to the Board Members after the meeting.

f. All major changes to the project's baseline schedule, scope, budget and risk posture are reviewed through the CCB.

C.2 Risk Review Board (RRB) Charter

C.2.1 Purpose

a. This document establishes the CoNNeCT Risk Review Board (RRB) and sets forth its responsibilities, membership, and relationship with other NASA Centers and external partners.

b. The purpose of the CoNNeCT RRB is to be a decision-making body, which validates or rejects candidate internal and external risks, and, provides status and tracking for top projects risks through the life of the CoNNeCT project.

C.2.2 Applicability/Scope

This Charter is applicable to the CoNNeCT Project, within the GRC Space Flight Systems Directorate.

C.2.3 Functions

The CoNNeCT RRB is chartered by the CoNNeCT Project Office. Each member of the CoNNeCT RRB is expected to represent the best interest of the Agency in the exercise of its functions. Members each contribute tactical insights of risk consequences including safety, technical, cost, and schedule impacts. The functions of the CoNNeCT RRB are as follows:

a. Review and validate (approve) risks generated by the CoNNeCT Team.

b. Track internal and external risks to closure.

c. Assess benefits of risk mitigation strategies.

C.2.4 Membership

The CoNNeCT RRB consists of members as follows:

a. CoNNeCT Project Manager, Chair

b. Deputy Project Manager Alternate Chair

c. CoNNeCT Chief Engineer

d. Safety and Mission Assurance

e. CoNNeCT PI/PS and WBS Leads (as required)

f. Risk Facilitator (non-voting)

g. Board decisions (in-board or out-of-board) require a minimum of PM, CE, and S&MA evaluation.

C.2.5 Meetings

a. The CoNNeCT RRB convenes on an as-needed basis.

b. The CoNNeCT RRB is chaired by the CoNNeCT Project Manager. The Deputy Project Manager for CoNNeCT is the alternate chair.

c. The Risk Facilitator sends out the agenda and assures the risk material in RMIT is ready for RRB review.

d. The risk originator or representative presents the risk information (risk statement and risk evaluation) to the board in the RMIT database. The board makes recommendations such as to modify the risk information and to mitigate, watch, or accept the risk. Risks with active mitigation or “watch” strategies are tracked.

e. Top Project Risks shall be communicated to the GRC Directors of Engineering and the Space Flight Systems Directorate and the SCaN Program Office.

f. The Risk Facilitator ensures all information is properly updated in RMIT, based upon the RRB decisions. .

C.3 Engineering Review Board (ERB) Charter

C.3.1 Purpose

a. This document establishes the CoNNeCT Engineering Review Board (ERB) and sets forth its responsibilities, membership, and relationship with other NASA Centers.

b. The purpose of the CoNNeCT ERB is to review major technical changes and provide recommendations to the CoNNeCT Control Board (CCB).

C.3.2 Applicability/Scope

This Charter is applicable to NASA GRC CoNNeCT Project, within the GRC Space Flight Systems Directorate.

C.3.3 Functions

The CoNNeCT ERB is chartered by the CoNNeCT Project Office. Each member of the CoNNeCT ERB is expected to represent the best interest of the Agency in the exercise of its functions. The functions of the CoNNeCT ERB are as follows:

a. Review and resolve engineering issues

b. Review Problem Reports

c. Serve as a Pre-Board and provide recommendations to the CCB.

C.3.4 Membership

The members of the CoNNeCT ERB are as follows:

a. CoNNeCT Chief Engineer, Chair

b. Lead Systems Engineer, Alternate Chair

c. Experiment Lead (as required)

d. Software Lead (as required)

e. Mission Operations Lead (as required)

f. Safety and Mission Assurance (as required)

g. Discipline Lead Engineers (as required)

h. Subject Matter Experts (as required)

i. PI/PS (as required)

C.3.5 Meetings

a. The CoNNeCT ERB convenes on an as needed basis.

b. The CoNNeCT ERB is chaired by the CoNNeCT Chief Engineer.

c. The CoNNeCT Chief Engineer, or his designee, sends out the agenda and presentation material to the Board Members prior to the meeting.

d. The Chief Engineer or his designee tracks action items and record all of the dispositions from the CoNNeCT ERB.

e. The Chief Engineer, or his designee, sends out the meeting minutes to the Board Members after the meeting.

C.4 Anomaly Resolution Board (ARB) Charter

C.4.1 Purpose

a. This document establishes the CoNNeCT Anomaly Resolution Board (ARB) and sets forth its responsibilities and membership.

b. The purpose of the CoNNeCT ARB is to review flight system and ground system anomalies and decide on disposition.

C.4.2 Applicability/Scope

This Charter is applicable to NASA GRC CoNNeCT Project, within the GRC Space Flight Systems Directorate.

C.4.3 Functions

The CoNNeCT ARB is chartered by the CoNNeCT Project Office. Each member of the CoNNeCT ARB is expected to represent the best interest of the Agency in the exercise of its functions. The functions of the CoNNeCT ARB are as follows:

a. Review and disposition GRC flight system and ground system anomalies as documented in problem reports.

C.4.4 Membership

The members of the CoNNeCT ARB are as follows:

a. Deputy Project Manager, Chair

b. Chief Engineer

c. SE&I Lead

d. S&MA

e. Cognizant engineers, as needed

f. WBS Lead(s), as needed

g. Software Lead, as needed for Software non-conformances.

C.4.5 Meetings

a. The ARB convenes on an as needed basis

b. The ARB is chaired by the CoNNeCT Deputy Project Manager (or their representative).

C.5 CoNNeCT Experiment Board (CEB) Charter

C.5.1 Purpose

a. This document establishes the CoNNeCT Experiment Board (CEB) and sets forth its responsibilities, membership, and relationship with other NASA Centers.

b. The purpose of the CoNNeCT CEB is to review, prioritize, and provide recommendations to the SCaN Systems Planning Division CoNNeCT Program Executive.

C.5.2 Applicability/Scope

This Charter is applicable to NASA GRC CoNNeCT Project, within the GRC Space Flight Systems Directorate.

C.5.3 Functions

The CEB is chartered by the CoNNeCT Project Office and the SCaN Systems Planning Division. Each member of the CEB is expected to represent the best interest of the Agency in the exercise of its functions. The functions of the CEB are as follows:

a. Release Announcement of Opportunities and supporting documentation to the community.

b. Review, evaluate, and rank proposals.

c. Select and recommend experiments that require SCaN funding for development to the SCaN Systems Division Manager.

d. Review and approve Experiment Plans that outline the experiment development plan and associated Payload Operations-provided SE&I and Mission Operations resources.

e. Prioritize and assist in resource conflict resolution among experimenters during planning, development and execution.

C.5.4 Membership

The members of the CEB are as follows:

a. Principle Investigator, Chair

b. Deputy Principle Investigator

c. Co-Investigators

d. SCaN Systems Planning Division CoNNeCT Program Executive

e. Experiment Manager, as required

f. Payload Operations SE&I Lead or his designee, as required

g. Payload Operations Mission Operations Lead, as required

h. Other subject matter experts, as required

i. Board decisions (in-board or out-of-board) require a minimum of PI approval. Decisions that negatively impact the project baseline budget require the concurrence of the PM.

C.5.5 Meetings

c. The CEB convenes on an as needed basis, nominally quarterly.

d. The CEB is chaired by the CoNNeCT PI (or their representative)

APPENDIX D EXAMPLE RISK CHART

Top CoNNeCT / SCAN Testbed Project Risks
Insufficient Processor Margin for High Rates

CoNNeCT Project **RISK FOCUS** **STATUS AS OF: 11/29/11**

Rank	Risk ID	Risk Statement	Approach & Plan	Comments
1 ↓	CONNE-134	***Insufficient Processor Margin for High Rates*** ***Given the:*** Given the PAS software can consume significant processor resources; ***There is a possibility that:*** there will be limited available processor idle time for CPU intensive tasks such as high data rates and networking, and future experiments may be limited. **Context:** The avionics processor utilization must support the flight system infrastructure software (e.g. telemetry, commands, pointing and tracking, Spacewire interface, avionics control, etc). Avionics software may be required to be rewritten in the future to minimize processor utilization for CPU intensive tasks, in order to enable some experiments.	**Mitigate** 1. Update FPGA SW on Dynamic Engineering Card for SpaceWire Communications. (completed 8-15-11) 2. Optimize SpWire Code (completed 9/30/11). 3. Gather metrics on CPU utilization for various SW tasks, such as SpW communications at different rates, APS tracking, APS logging, etc., by 12/2/11. 4. Perform assessment of other candidate SW tasks for code optimization, by 2/29/12. 5. Perform targeted code improvements and test on GIU, by 4/28/12.	**STATUS:** • Processor can handle the high CPU intensive tasks, but not ALL of them simultaneously, such APS Logging, and BER tracking. APS Code has been optimized and tested on GIU with good results, indicating system will meet requirements. Baseline performance of Flight System will be determined during Comm Performance #2 Testing, by 12/2/11.

Risk Category: Technical and Cost

LOW **Risk Score:** $2_L \times 3_C$ **Timeframe:** Near-term **Owner:** Todd Tofil